

SYNOPSIS OF THE CALANOID CRUSTACEANS, EXCLUSIVE OF THE DIAPTOMIDAE, FOUND IN FRESH AND BRACKISH WATERS, CHIEFLY OF NORTH AMERICA

By C. DWIGHT MARSH¹

Honorary Custodian of Fresh-water Copepods, Division of Marine Invertebrates, United States National Museum

The term Calanoida for a suborder of Copepoda is used herein as defined by G. O. Sars. The calanoid species found in North and South America are in the families Centropagidae, Diaptomidae, Pseudodiaptomidae, Senecellidae, and Temoridae. Though this paper is intended specifically to cover the forms of North America, the discussion of species is not limited to those of that continent, but in some cases includes those of the world.

Among the Centropagidae of North America are found the genera *Limnocalanus* and *Osphranticum*. The Temoridae of North America include the genera *Eurytemora*, *Heterocope*, and *Epischura*. The family Pseudodiaptomidae includes the genera *Pseudodiaptomus* and *Schmackeria*. The new family Senecellidae has only one genus, *Senecella*.

KEY TO THE GENERA OF THE FRESH-WATER CALANOIDA

- | | |
|--|------------------|
| 1. Endopods of feet 1 to 5, 2-segmented..... | Calamoecia Brady |
| Endopods of feet 1 to 4, 1-segmented, fifth feet of female without endopods..... | 2 |
| Endopods of first feet, 1-segmented; feet 2 to 4, 2-segmented..... | 3 |
| Endopods of feet 1 to 4, 3-segmented..... | 4 |
| Endopods of feet 1 to 5, 3-segmented..... | 7 |
| Endopods of first feet, 2-segmented; feet 2 to 4, 3-segmented; endopods of female fifth feet, 2-segmented..... | 9 |
| Endopods of first feet, 1-segmented; second feet, 2-segmented; third and fourth feet, 3-segmented..... | Senecella Juday |
| 2. Abdomen of male symmetrical, distal segment of exopod of female fifth foot terminating in a long spine..... | Heterocope Sars |
| Abdomen of male asymmetrical, distal segment of exopod of female fifth foot not terminating in a spine..... | Epischura Forbes |

¹ Doctor Marsh died on Apr. 23, 1932, just one month after this paper was submitted for publication. A complete list of Doctor Marsh's copepod papers is given on pp. 57 and 58.—EDITOR.

3. Exopods of feet 1 to 4, 3-segmented; in female fifth feet endopods 2-segmented..... Brunella Smith
 Exopods of first feet, 1-segmented; feet 2 to 4, 2-segmented; female fifth feet without endopods..... Eurytemora Giesbrecht
4. First antennae 20- to 22-segmented..... 5
 First antennae 25-segmented..... 6
5. Second segment of basipod of left fifth foot of male with long curved projection from inner border.... Schmackeria Poppe and Richard
 Second segment of basipod of left fifth foot of male without long curved projection from inner border..... Pseudodiptomus Herrick
6. Female fifth feet without endopods, male fifth feet with terminal hook on right foot only, and hook turned outward instead of inward..... Poppella Richard
 Female fifth feet with endopods, male fifth feet with terminal hook on both exopods..... 10
 Female fifth feet with endopods, male fifth feet with terminal hook on right exopod only, fourth feet with a long curved spine on inner distal angle on first basal segment.... Gladioferens Henry
7. Exopods of second antennae 5-segmented, segments 2, 3, and 4 being short..... Parabroteas Mrázek²
 Exopods of second antennae 6-segmented, segments 2 to 5 being short..... Sinocalanus Burckhardt
 Exopods of second antennae 7-segmented, segments 1, 3, 4, 5, and 6 being short..... 8
8. Furca short..... Osphianticum Forbes
 Furca long..... Limnocalanus Sars
9. In male fifth feet both exopods terminating in an elongated hook; in female fifth feet exopods distinctly 3-segmented. Metaboeckella Ekman³
 In male fifth feet only right exopod terminating in an elongated hook; in female fifth feet third segments of exopods are either rudimentary or lacking..... 11
10. Endopod of right fifth foot of male rudimentary, 1- to 3-segmented, without setae..... Boeckella de Guerne and Richard
 Endopod of right fifth foot of male 3-segmented, with setae. Pseudoboeckella Mrázek
11. Female abdomen 2-segmented, maxillipeds prominent..... 12
 Female abdomen 3-segmented, maxillipeds not prominent..... 13
12. Left exopod of male fifth foot armed with hook and acute spine. Lovenula Schmeil⁴
 Left exopod of male fifth foot armed with two stout spines and hyaline lamella..... Paradiptomus Sars
13. Exopod of left fifth foot of male with stout curved spine in posterior surface and a small terminal spine... Metadiptomus Methuen
 Exopod of left fifth foot of male armed with two small appendages that may be either digitate or spiniform... Diptomus Westwood⁵

² Synonyms: *Limnocalanus* Daday, *Gigantella* Ekman, *Parabroteas* Ekman.

³ Synonym: *Boeckella (dilatata)* Sars.

⁴ Synonym: *Adiaptomus* Cooper.

⁵ Synonym: *Hemidiptomus* Sars.

Family CENTROPAGIDAE

Genus LIMNOCALANUS Sars, 1863

Body long and narrow. The cephalothorax is composed of six segments, is elongated oval in form, with its greatest width at about the middle. The last cephalothoracic segment is not produced laterally. The abdomen is slender, composed of three segments in the female and five in the male. The furcal rami are elongated, ciliate on the internal margins; they are terminated by five elongated setae, of which the second from the inside is the longest, and one short slender seta on the inner margin. The external seta is located back of the end of the ramus. The first antennae are 25-segmented, the terminal segment being very short.

The right antenna of the male is geniculated and composed of 22 segments; of the normal 25 segments, 19 to 21 and 22 to 23 are united. The terminal portion is composed of four or five segments. In *L. macrurus* and *L. johanseni*, the typical form of this terminal portion is that shown in Plate 1, Figure 8; the first of the group, the nineteenth segment of the antenna, is elongated, the second somewhat shorter, the third less than half the length of the second, and the terminal one very short. In exceptional cases in both these species the first segment is divided as shown in Plate 1, Figure 9. In all examined specimens of *L. grimaldii* there have been five segments, as in Figure 9. Both Sars (1897) and Willey (1923) give the number of segments as five.

In the second antennae (pl. 1, fig. 5) the exopod is longer than the endopod and is composed of seven segments, of which the first and the third, fourth, fifth, and sixth are short. All the swimming feet are biramose, the fifth pair both in the male and female differing from the others. Both rami of feet 1 to 4 are 3-segmented, the endopods being shorter than the exopods. The outer rami of the fifth pair of the female are 3-segmented, and the second segment is produced on the inner distal angle into a stout curved process. (Pl. 3, fig. 3.)

The exopods of the fifth feet of the male (pl. 13, fig. 5) are 2- or 3-segmented. The second segment of the right exopod is short, truncated, and produced on the inner side into a stout hook. The second segment of the left exopod is elongate, ciliate on the inner border, and in addition to a terminal spine bears three lateral spines on the outer border.

KEY TO THE SPECIES OF LIMNOCALANUS

1. Both exopods of male fifth feet 2-segmented, length of furcal rami about seven times width..... 2
 Right exopod of male fifth feet distinctly 3-segmented, length of furcal rami about three times width..... *johanseni* Marsh
2. Head distinctly vaulted, with a cervical depression; sides of last thoracic segment rounded; female antennae hardly reaching second abdominal segment. Fresh water..... *macrurus* Sars
 Head not distinctly vaulted, no cervical depression; sides of last thoracic segment pointed; female antennae extending to base of furca. Marine and brackish water..... *grimaldii* (de Guerne)

LIMNOCALANUS MACRURUS Sars

PLATE 1. FIGURES 2, 3, 5; PLATE 2; PLATE 3, FIGURES 1-3; PLATE 13, FIGURE 5

Limnocalanus macrurus Sars, 1863, pp. 228, 229; 1903, pp. 81-83, pls. 55, 56.—FORBES, 1882, p. 648.—NORDQUIST, 1888, pp. 31-37, pl. 1, figs. 9-11, pl. 2, figs. 1-5, pl. 3, figs. 1-4.—DE GUERNE and RICHARD, 1889, p. 77, pl. 4, figs. 5, 11, 12.—HERRICK and TURNER, 1895, p. 49, pl. 1, figs. 1-4.—SCHACHT, 1898, pp. 238-244.—GIESBRECHT and SCHMEIL, 1898, pp. 58, 59.—MARSH, 1918, p. 774, fig. 1212.

Limnocalanus macrurus var. *auctus* FORBES, 1891, pp. 706, 707.—MARSH, 1893, p. 201, pl. 4, fig. 7; 1895, pp. 11, 12, pl. 4, figs. 1, 2, pl. 5, figs. 1-3.

Limnocalanus grimaldii var. *macrurus* RYLOV, 1922, pp. 13, 14, fig. 5, *a-d*; 1930, pp. 64-69, fig. 5, 1 and 2, fig. 13, 3 and 4, fig. 15, 1-3.

The head, seen in profile, is distinctly vaulted, and there is a more or less clearly marked cervical depression. (Pl. 1, figs. 2, 3.) The last cephalothoracic segment is not broadened, and its sides are rounded. There are spines on the distal border of the second abdominal segment of the female and on segments 2 to 4 of the male. The length of the furcal rami is about seven times the width. The first antennae hardly reach the second abdominal segment. The armature of the first antennae of the male is shown in Plate 2. The exopod of the second antenna has the typical form of the genus. (Pl. 1, fig. 5.)

In Plate 3, Figures 1 and 2, are shown the swimming feet 1 and 2, and in Figure 3 the fifth foot of the female.

In the male fifth foot (pl. 13, fig. 5), the right exopod is 2-segmented, but the second segment has a projection that may be considered as a rudimentary third segment; the right exopod and endopod are of about equal length. The left exopod is larger than the endopod.

The size, as given by different authors, varies somewhat: Females, 2.2 to 3.15 mm; males, 2.2 to 2.78 mm.

This species is considered a fresh-water form. It occurs in many localities in Scandinavia and in Finland. In America it is in all the Great Lakes, in Green Lake, Wis., and in Lake Nipigon, Canada.

Birge and Juday (1914) found it in Cayuga, Seneca, Canandaigua, Skaneateles, and Owasco Lakes in New York. Bajkov (1930) reported it from Lake Winnipeg. Stephensen (1913) and Haberbosch (1916) reported it from Greenland.

The description of this species and of the genus is largely from the original account by Sars, but modified somewhat by the results of later investigations. The enlarged head and cervical depression are certainly not so marked in American material as is indicated by the figures by Sars, but this peculiarity is less marked in Nordquist's drawings. In Plate 1, Figure 2, it is much less marked than in Figure 3.

There is some lack of agreement in regard to the number of segments in the exopod of the second antenna. This was discussed by Schacht (1898), and he is correct in considering the exopod as 7-segmented, not only in *L. macrurus* but in the genus; it is evident that the lack of agreement is due to the indistinctness with which the separation of the middle segments is marked.

Remarks.—*L. macrurus* is generally considered as belonging to the *fauna relicta*; that is, it is a salt-water form that has gradually become adapted to a fresh-water environment. Generally speaking, it is found only in fairly deep lakes and most abundantly at considerable depths. Its habits with relation to temperature and light are discussed by Marsh, 1897 (pp. 200-202). Rylov (1922 and 1930) lists this species as *L. grimaldii* var. *macrurus*. As there is no available translation of his Russian text, I can not state why he has made this change.

LIMNOCALANUS GRIMALDII (de Guerne)

PLATE 1, FIGURES 4, 6, 7

Centropages grimaldii DE GUERNE, 1886, pp. 276-285.

Limnocalanus macrurus NORDQUIST, 1888, p. 31.—DE GUERNE and RICHARD, 1889, pp. 77, 78.—SCHACHT, 1898, p. 243.

Limnocalanus grimaldii SARS, 1897, pp. 39-49, pl. 4, figs. 1-18; 1898, p. 12, pl. 8, fig. 7.—WILLEY, 1920, p. 11K.—PESTA, 1928, p. 27, fig. 19, a-c.—RYLOV, 1930, pp. 63, 64, fig. 13, 1 and 2, fig. 14, 1 and 2.

L. grimaldii differs from *L. macrurus* in the characters given in the key, that is, in the flat head with no cervical depression, in the pointed sides of the last cephalothoracic segment, and in the greater length of the female antennae. While the number of segments in the terminal portion of the right antenna of the male is typically in *L. macrurus* four and, exceptionally, five, it appears to be in *L. grimaldii* always five, as shown in Plate 1, Figure 7. In other respects *L. grimaldii* is identical with *L. macrurus*.

Plate 1, Figure 6, shows the right fifth foot of the male, Figure 4 exopod of left fifth foot, and Figure 7 fifth foot of female.

Remarks.—Nordquist (1888), de Guerne and Richard (1889), and Schacht (1898) considered that there is not sufficient difference to warrant the adoption of another specific name. It is a fact, however, that the differences as given above exist, and it is probably best to recognize them by a specific name.

This species was originally described from material collected in the Gulf of Finland. It has been found in many parts of the eastern Baltic as well as the Gulf of Finland and the Gulf of Bothnia, on Kolguev Island in the Kara Sea, at the mouth of the Jana, in the sea off Spitsbergen, and in Greenland. Sars found it in the Caspian Sea and in 1897 gave a detailed description of it. Willey (1920) reported it from Collinson Point, Alaska; this collection was made by Frits Johansen in the Arctic Ocean, about 100 yards from shore in about 1 fathom of water. *L. johanseni* was collected inland from that point in a pond about 4 feet deep; this pond apparently had no connection with the ocean, and the location where *L. grimaldii* was collected was not connected in any way with fresh water. Willey (1923) reported finding *L. grimaldii* in large numbers in the stomach contents of the capelin (*Mallotus villosus*).

Sars (1898) stated that the specimens from the mouth of the Jana were much larger than those from the Caspian, and expressed his belief that *L. grimaldii* is a more Arctic form and that its presence in the Baltic and Caspian Seas is evidence of a former connection of those basins with the Arctic. Its occurrence at the mouth of the Jana, in the Kara Sea, at Kolguev Island, Spitsbergen, Greenland, and Collinson Point would indicate a wide distribution in the Arctic.

The size of the male, as given by different authors, is 2 to 2.5 mm; of the female, 2.8 to 3.6 mm.

The segmentation regeneration of the terminal part of the right antenna of the male is discussed under the description of the genus.

LIMNOCALANUS JOHANSENI Marsh

PLATE 1, FIGURES 1, 8, 9; PLATE 3, FIGURES 4-7; PLATE 13, FIGURE 6

Limnocalanus johanseni MARSH, 1920, pp. 3j-4j, pl. 1, figs. 1-8.

The head, as shown in Plate 1, Figure 1, is not vaulted as in *L. macrurus*. The front is armed with two projections. The last cephalothoracic segment is rounded on the sides and each side is armed with a small spine, which may be sharp, as in Plate 3, Figure 5, or blunt, as in Plate 3, Figure 6.

In the abdomen of the female (pl. 13, fig. 6) the first segment is somewhat expanded laterally and is about twice as long as the second; the third segment is slightly longer than the second. The

length of the furcal rami is three times the width. They are about half again as long as the third segment. They are ciliate on the inner borders but not covered with coarse hairs or spines as in *L. macrurus*. In the male abdomen (pl. 3, fig. 4) the first three segments are nearly equal in length and the fourth and fifth are somewhat shorter.

The first antennae, when reflexed, reach the second abdominal segment. The terminal portion of the right antenna of the male is usually 4-segmented (pl. 1, fig. 8), but sometimes is 5-segmented (pl. 1, fig. 9). The other cephalothoracic appendages of the female are like *L. macrurus*.

The left fifth foot of the male (pl. 3, fig. 7) is like that of *L. macrurus*, but the terminal spine of the second segment of the exopod is somewhat longer. The exopod of the right fifth foot of the male is distinctly 3-segmented. The first segment has a spine at the outer distal angle. The second segment is prolonged into the customary hook at the inner distal angle; at the outer distal angle is a short, blunt, curved hook. The third segment is attached by a distinct joint just within the outer hook: It is hook-shaped, curved inward, pointed at the end, about twice the length of the second segment and one-third to one-half its width; it has upon its dorsal surface a curved spine.

Average length: Females, 2.99 mm; males, 2.6 mm.

Remarks.—*L. johanseni* has, so far, been found in only one locality, in a pond on the coast of the Arctic Sea at Collinson Point.

The distinguishing features of the species are the short furca armed with fine cilia rather than coarse hairs or spines and the 3-segmented exopod of the male right fifth foot.

Genus OSPHRANTICUM Forbes, 1882

Only one species of *Osphranticum* has been found; therefore the description of the species will serve also for the genus.

OSPHRANTICUM LABRONECTUM Forbes

PLATES 4, 5

Potomoichetor fucosus HERRICK, 1882, p. 224, pl. 2, figs. 12-14, pl. 3, figs. 1-3, 13, 14.

Osphranticum labronectum FORBES, 1882, p. 645, pl. 8, figs. 24, 28, 29, pl. 9, figs. 1, 2, 4, 5, 7, 9.—HERRICK, 1884, p. 134, pl. Q², figs. 1-8, 13, 14; 1887, p. 12.—DE GUERNE and RICHARD, 1889, pp. 96, 97, pl. 4, figs. 1, 2.—HERRICK and TURNER, 1895, p. 86, pl. 12, figs. 1-8, 13, 14, pl. 59, figs. 7, 8.—SCHACHT, 1898, pp. 230-235.—GIESBRECHT and SCHMEIL, 1898, p. 59.—TOLLINGER, 1911, pp. 151-153, fig. M⁴.—JUDAY, 1915, p. 241.—MARSH, 1918, p. 774, fig. 1211.

The cephalothorax is symmetrically oval (pl. 4, fig. 1), composed of six segments, which decrease in length from before backward. The first segment about equals the three following segments. The last segment is bluntly rounded at the sides, and is not armed with spines.

The abdomen of the female (pl. 4, fig. 2) consists of four segments, decreasing in length from the front backward. The furcal rami about equal in length the third segment and are ciliate on the inner border. The egg sacs are very large, extending nearly to the ends of the furcal setae. The abdomen of the male (pl. 5, fig. 4) consists of five segments, the fifth being short, hardly half as long as the fourth. The furcal rami are ciliate. The furcal setae are long and plumose, the fourth from the outside being the longest. The antennae are 25-segmented and equal in length the cephalothorax or a little more. The right antenna of the male (pl. 4, fig. 3) is geniculate between the eighteenth and nineteenth segments. The antennae are richly supplied with sensory clubs. The segmentation of the second antennae (pl. 5, fig. 5) is like that of *Diaptomus* and *Limnocalanus*. The mandible is shown in Plate 4, Figure 5. Swimming feet 1 to 5 are biramose and in all the endopods are 3-segmented. There is a seta on the inner side of the first basal segment of all feet except the fifth.

The fifth feet of the female (pl. 5, fig. 1) are alike. The first basal segment is armed on the outer margin with a very delicate hair. The second segment is unarmed. The first and second segments of the exopod have a stout spine at the outer distal angle; the inner distal angle of the second segment is prolonged into a slightly curved lamellate hook, which reaches the end of the third segment. The third segment is armed with three spines and four setae; there is also a short acute terminal spine.

The first segment of the exopod is unarmed. The second segment has a long seta at the inner distal angle; the third segment has a lamellate spine on the outer margin and, on the inner margin and the end, five setae.

In the male the seta on the inner distal angle of the second segment of the exopod of the fourth foot is peculiar in that the base is much swollen, as shown in Plate 5, Figure 3, and the third segment of the exopod is hollowed out on the inner proximal angle to receive the base of this seta. In Plate 5, Figure 2, is shown for comparison the female fourth foot, in which there is a slight indication of this enlargement of the seta of the second segment of the exopod, but no modification of the inner proximal angle of the third segment.

Each of the second basal segments of the male fifth foot (pl. 4, fig. 4) is armed on the outer margin at about one-third its length with a short hair. The exopod of the right foot is 2-segmented; the first segment is trapezoidal in form, with a stout spine at the outer distal angle. The second segment is about three times as long as its width; it has a stout spine about one-half the length of the outer margin and three nearly equal terminal spines; these spines are nearly equal in length to the segment; the inner spine is slightly the longest and is slightly curved inward, while the other two are straight. This segment has on its inner proximal angle a prominent rounded pad covered with short hairs.

The left exopod is 3-segmented. Segments 1 and 2 are about twice as long as broad, and bear at the outer distal angles a rather slender spine about equal in length to the segment. The third segment is smaller than the first and second, about twice as long as its breadth, and has three terminal spines; of these spines the outer is the longest, being about two and a half times the length of the segment; the inner is small and rudimentary.

Length, according to de Guerne and Richard, 2-2.5 mm; Schacht, female, 1.7 mm, male, 1.4 mm; Herrick (1887), 2.3 mm. Those measured by the author slightly exceed the figures of Schacht.

Remarks.—The original description by Forbes was from material collected near Normal, Ill. He also found it in Iroquois County, Ill. Herrick (1882) described his *Potomoichetor fucosus* from two localities in Minnesota. Herrick (1887) notes its occurrence in Alabama. De Guerne and Richard in 1889 recorded it from Portland, Oreg. Schacht added to previous records Havana, Ill., and Wyoming. Juday (1915) found it at Puerto Barrios and Los Amates, Guatemala. Creaser (1931) found it in crayfish burrows at Van Buren, Carter County, Ark. The author has found it in collections made by Dr. E. A. Birge at Lake Charles, La., and Bertig, Ark.; by Dr. V. E. Shelford in collections made near Gary, Ind.; and by H. K. Harring in the vicinity of Washington, D. C.

This is a somewhat erratic distribution, and it seems strange that the species has not yet been found in intervening localities. It is not evident why it has not been found in other places. There are few data in regard to its annual distribution. Presumably the Illinois collections were made in the summer. Most of the author's material was collected in the fall, but one gathering was made in March. Juday's Central American collection was made in February, but winter collections in Panama have not contained this species.

Apparently, so far as present knowledge is concerned, it is in the United States practically a Mississippi Valley species, although we have the records of Oregon and Wyoming.

The foregoing description is compiled from those of preceding authors with some additions and changes resulting from a study of the author's preparations. Herrick found the antennae 24-segmented. Forbes and, after him, Schacht considered them 24-segmented. A careful study of the preparations at hand leads the author to consider them 25-segmented. The separation of the first two segments is not always easy to distinguish. Moreover, the basal segment is not jointed, and, perhaps on this account, has not been counted by some authors.

Apparently the peculiar enlargement of the seta on the second segment of the exopod of the male fourth foot with the hollow of the second segment has not been noted by others. This was found constant in all the male fourth feet examined.

Family TEMORIDAE

Genus EURYTEMORA Giesbrecht, 1881

Last thoracic segment separated from the preceding, often expanded into wings, symmetrical in male. Abdomen of female 3-segmented. Abdomen of male 5-segmented.

First antennae 24-segmented; but *E. grimmi* has 25 segments. Terminal portion of right antenna of male generally stated to be 2-segmented. Giesbrecht and Schmeil (1898) state "two, seldom more." Apparently in most cases there is a distinct short terminal segment, which would make the typical number three. Giesbrecht (1882) states that in *E. hirundo* it is 2-segmented. Sars's figure for *E. grimmi* shows five segments, while his figure for *E. gracilis* shows four. Probably it is safe to say that the terminal portion of the right antenna of the male ordinarily consists of three segments, but in some cases there are more.

The exopod of the second antenna, as in *Diaptomus*, consists of seven segments, with four short ones in the middle. The endopod of the maxilliped consists of five segments, as in *Diaptomus*, *Limnocalanus*, and *Osphranticum*. The endopod of the first foot is 1-segmented; of feet 2 to 4, 2-segmented. The penultimate segment of the fifth foot of the female has a process from its inner distal angle. The right fifth foot of the male has four or five segments.

KEY TO THE SPECIES OF EURYTEMORA (FROM CHARACTERS OF FEMALE)

- | | |
|---|--|
| 1. Third segment of fifth foot with one external spine..... | 2 |
| Third segment of fifth foot with two external spines..... | 3 |
| 2. Last cephalothoracic segment expanded, with large wings | |
| pointed backward..... | <i>velox</i> (Lilljeborg) ⁶ |
| Last cephalothoracic segment without wings, rounded behind. | <i>grimmi</i> (Sars) |

⁶ Synonyms: *E. adleri* Schiklejew and *E. lacunculata* (Fischer).

3. Process of penultimate segment of fifth foot approximately perpendicular to axis of foot----- 4
 Process of penultimate segment of fifth foot bent distally----- 12
4. Dorsal surface of furca and terminal abdominal segment armed with spines----- 5
 Dorsal surface of furca and terminal abdominal segment not armed with spines----- 11
5. First abdominal segment not definitely enlarged laterally----- 6
 First abdominal segment more or less enlarged laterally----- 7
6. Sides of last cephalothoracic segment not expanded laterally, rounded; process of penultimate segment of fifth foot of female about one-half length of ultimate segment----- *canadensis* Marsh
 Sides of last cephalothoracic segment expanded in pointed wings; process of penultimate segment of fifth foot of female nearly twice as long as ultimate segment----- *americana* Williams
7. Proximal half of first abdominal segment strongly expanded----- 8
 First abdominal segment expanded in two lobes on each side----- 10
8. Wings of last cephalothoracic segment pointed----- 9
 Wings of last cephalothoracic segment rounded----- *hirundo* (Giesbrecht)
9. Furca of female five to seven times as long as broad; antennae slightly exceeding second thoracic segment; wings of last cephalothoracic segment extending outward----- *affinis* (Poppe)⁷
 Furca of female 8 to 12 times as long as broad; antennae equaling or nearly equaling cephalothorax; slenderer and smaller than *affinis*; wings pointed or rounded, not distinctly projecting outward----- *hirundoides* (Nordquist)⁸
10. Wings of last cephalothoracic segment pointed; furca three or four times as long as broad----- *raboti* Richard
 Wings of last cephalothoracic segment blunt; furca seven times as long as broad----- *composita* Keiser
11. Sides of last cephalothoracic segment not expanded outward.
lacustris (Poppe)
 Sides of last cephalothoracic segment markedly expanded outward----- 13
12. Wings of last cephalothoracic segment extended backward beyond first abdominal segment; process of penultimate segment of fifth foot dentate on both sides, extended distad beyond end of terminal spine of ultimate segment.
herdmani Thompson and Scott
 Wings of last cephalothoracic segment not reaching end of first abdominal segment; process of penultimate segment of fifth foot dentate on outer side, not reaching ultimate segment.
johanseni Willey
13. Wings of last cephalothoracic segment expanded out and distad; process of penultimate segment of fifth foot not dentate.
gracilis (Sars)
 Wings of last cephalothoracic segment recurved at tip; process of penultimate segment of fifth foot dentate----- *tolli* Rylov

⁷ Synonym: *E. adleri*.

⁸ Olofsson considers *hirundo* and *hirundoides* as variations of *affinis*. Nordquist states *hirundoides* to be the connecting link between *affinis* and *hirundo*. Schmeil considers *hirundo* and *hirundoides* good species. DeLint considers *hirundoides* a good variation.

EURYTEMORA AFFINIS (Poppe)

PLATE 6, FIGURES 1-3, 8

Temora velox LILLJEBORG, 1853, p. 77, pl. 19, figs. 9, 10, pl. 20, fig. 1.

Temora affinis POPPE, 1880, p. 55, pl. 3.—HERRICK, 1884, p. 133, pl. H, figs. 8-16.

Temorella affinis CLAUS, 1881, p. 491, pl. 2, figs. 8-14.—HERRICK, 1887, p. 9, pl. 1, figs. 3-6, pl. 2, figs. 9-12.—CANU, 1888, p. 88, pl. 7, figs. 1-3.

Temorella affinis var. *hispida* NORDQUIST, 1888, p. 53, pl. 5, figs. 1, 6, 7, 10, pl. 6, figs. 4, 5.

Eurytemora affinis DE GUERNE and RICHARD, 1889, p. 84, figs. 46, 47.—RICHARD, 1891, p. 247, figs. 13, 14.—BRADY, 1891, p. 42, pl. 13, figs. 6-9.—HERRICK and TURNER, 1895, p. 51, pl. 1, figs. 5-10, pl. 60, figs. 8-15.—SCHMEL, 1896, p. 114, pl. 8, fig. 11, pl. 11, figs. 1-11.—GIESBRECHT and SCHMEL, 1898, p. 103.—FOSTER, 1904, p. 73.—MARSH, 1918, p. 756.—RYLOV, 1922, p. 45, fig. 24, a-d; 1930, p. 224, fig. 74, 1-4.—PESTA, 1928, p. 47, fig. 39, A, B.—WILSON, 1932,⁹ pp. 111, 112, fig. 74.

Eurytemora thompsoni WILLEY, 1923, p. 313, fig. 7.

Last cephalothoracic segment expanded into two large pointed wings extending distad and outward with nearly straight outer borders. (Pl. 6, fig. 8.) The first abdominal segment projects on the ventral side; it is expanded laterally for about one-half its length, then narrowed suddenly. (Pl. 6, figs. 1, 3.) On the ventral side are two triangular projections from the sides of the anterior part of the segment, as shown in Plate 6, Figure 3. The second segment is very short. The furcal rami are ciliate on their inner borders, and, in the female, the dorsal surfaces of the furcae and of the last abdominal segment are thickly beset with small spines. The rami, in the female, are five to seven times as long as wide; in the male (pl. 6, fig. 2) the length is much greater. The first antennae vary in length, sometimes nearly equaling the cephalothorax, but generally being from two-thirds to three-fourths its length.

The fifth foot of the female (pl. 6, fig. 8) has two spines on the external border of the first segment of the exopod; the process of the inner side of this segment is large, projecting inward and slightly distally; it is considerably longer than the second segment of the exopod.

The last two segments of the exopod of the right fifth foot of the male are united and the proximal portion is swollen. The last segment of the left fifth foot is terminated by a rounded process and a digitate projection. This is shown in Plate 6, Figure 6, of *E. hirundoides*.

The length of the species, as given by various authors, evidently refers to the female and is about 1.5 mm. Measurements of American specimens were about the same, the females measuring 1.5 mm or somewhat less, and the males 1 to 1.25 mm.

⁹ References herein to Doctor Wilson's monograph on the copepods of the Woods Hole region were added during the course of editing.—EDITOR.

Occurrence.—Pope described *E. affinis* from material collected near the mouths of several German rivers. It may be found in salt, brackish, or fresh water. It occurs in France, Germany, Sweden, England, and Scotland, in the fresh-water lagoons of the Caspian Sea at the mouth of the Volga, in fresh water in central Asia, and on Kolguev Island. Herrick (1884) was the first to report it in America, finding it in the shallow bays along the Gulf of Mexico. Foster (1904) gave localities near New Orleans. Pearse (1906) recorded it from Nantucket Island and wrote me that he had seen it in 1911 at Tampico, Mexico. Marsh (1912) reported it from St. Johns River and Little Lake George, Fla., from Black Bayou, Miss., and Flat Lake, La. It has also been found in Shreveport, La. Willey (1923) found it in Lake St. John, a fresh-water lake. Its distribution is interesting, for in many cases it has been found a long distance from salt water.

EURYTEMORA GRACILIS (Sars)

Temorella gracilis Sars, 1898, p. 336, pl. 8, figs. 8-18.

Eurytemora gracilis WILLEY, 1920, p. 11K, fig. 3, 3 and 4.—RYLOV, 1930, p. 228, fig. 75, 1-4.

E. gracilis is a slender form closely resembling *E. affinis*; it differs from this species in that the head is somewhat broader, the wings of the last cephalothoracic segment flare out laterally, and the last abdominal segment and the furca are not armed with spines.

Length: Female, 1.4 mm; male, 1.25 mm.

Occurrence.—Sars reported it in the lower part of the river Jana. Willey found a single damaged female in the collections of the Canadian Arctic expedition.

EURYTEMORA CANADENSIS Marsh

PLATE 7; PLATE 8, FIGURES 5, 6

Eurytemora canadensis Marsh, 1920, pp. 4J, 5J, pl. 1, figs. 9-12, pl. 2, figs. 1, 2, 4, 7.

Female.—Cephalothorax oval, the greatest width being forward of the middle. (Pl. 7, fig. 6.) The last cephalothoracic segment extends backward but is not produced laterally (pl. 8, fig. 5); the wings are rounded and the margins are armed with a few minute hairs. The first abdominal segment is slightly expanded laterally (pl. 7, fig. 4) and is armed on the outer edge with scattered fine hairs. The first and third abdominal segments are about equal in length and are about one and one-half times the length of the second. The furcal rami are slender, about eight times as long as wide; they are ciliate on both inner and outer borders except distad of the lateral seta, where there are one or two hairs; there are some hairs on the surface.

The antennae extend nearly or quite to the fourth cephalothoracic segment. The swimming feet are typical of the genus. Plate 8, Figure 6, shows the fourth foot. In the fifth foot (pl. 7, fig. 2) the second segment of the basipod has a seta about midway of its outer margin. The first segment of the exopod is about twice as long as broad; it has a long spine at about midway of its outer border and another at its outer distal angle; the unguiform process of the inner distal angle projects at an angle of about 45° with the axis of the segment; the distal border of this process is armed with 6 to 11 teeth. The second segment of the exopod is about one-half as long as the first and has a spine at the outer distal angle and a long terminal spine.

Length, 1.9 to 2.25 mm.

Male.—The cephalothorax is narrower than in the female, and elliptical rather than oval in outline. The abdomen (pl. 7, fig. 3) is slender, the segments being of about equal lengths. The furcal rami have about the same proportions as in the female; they are ciliate on the inner border, and very sparsely ciliate on the outer. The fifth foot is shown in Plate 7, Figure 5; the right foot is distinctly 4-segmented.

Length, 1.95 to 2.1 mm. Collected by Frits Johansen, of the Canadian Arctic expedition, at Bernard Harbor.

EURYTEMORA HERDMANI Thompson and Scott

PLATE 8, FIGURES 1-3

Eurytemora herdmani THOMPSON and SCOTT, 1897, p. 78, pl. 5, figs. 1-11.—
GIESBRECHT and SCHMELL, 1898, p. 103.—SHARPE, 1910, p. 410, fig. 2.—
WILSON, 1932, pp. 112-114, fig. 75.

Wings of last cephalothoracic segment very largely developed, extending distad beyond the first abdominal segment. (Pl. 8, fig. 2.) The first abdominal segment is expanded in the distal half into two rounded projections extending distad. The first antennae are about as long as the cephalothorax. In the fifth foot of the female (pl. 8, fig. 1) the first segment of the exopod has two spines on the outer border. The process of the internal border is long, extending distad beyond the end of the terminal spine of the second exopod; it is armed with dentations on both inner and outer borders. The last two segments of the exopod of the right fifth foot of the male are not united. (Pl. 8, fig. 3.)

Length, 1.6 mm.

Occurrence.—This species was described from material collected in the Gulf of St. Lawrence. Williams (1906) reported it in Narragansett Bay; Sharpe (1910) and Wilson (1932) from Woods Hole,

Mass.; and Willey (1920) from several stations of the Canadian Arctic expedition. Willey (1923) also reported it from Miramichi Bay and River, Labrador, from Hudson Bay, and from contents of stomachs of shad caught in Scotsman Bay, Nova Scotia.

EURYTEMORA HIRUNDOIDES (Nordquist)

PLATE 6, FIGURES 4-7; PLATE 14, FIGURE 9

Temorella affinis var. *hirundoides* NORDQUIST, 1888, p. 48, pl. 4, figs. 5-11, pl. 5, fig. 5.

Eurytemora affinis var. *hirundoides* GIESBRECHT and SCHMEIL, 1898, p. 104.

Eurytemora hirundoides SARS, 1902, p. 102, pl. 69.—VAN BREEMEN, 1908, p. 101, fig. 117, a-d.—SHARPE, 1910, p. 411, fig. 3.—DE LINT, 1922, p. 81, pl. 4.—ESTERLY, 1924, p. 93, fig. F, 1-12, fig. G, 1-9.—PESTA, 1928, p. 50, fig. 41, a-c.—CAMPBELL, 1929, p. 315.—WILSON, 1932, pp. 110, 111, fig. 73.

A long slender species.

Female.—The wings of the last thoracic segment resemble those of *E. affinis* but extend outward less; they are pointed or rounded. The first abdominal segment (pl. 14, fig. 9), like *E. affinis*, is laterally expanded in the proximal half and is narrowly constricted at about the middle; these expansions bear on each side a small spine. The third abdominal segment is armed on the dorsal side with fine spines.

The furcal rami are ciliate on the inner margin, and on the outer margin distad of the lateral seta; the dorsal surface like that of the third segment is armed with fine spines. The length of the rami is 8 to 12 times the breadth. The first antennae are nearly as long as the cephalothorax. The fifth foot (pl. 6, fig. 5) is like that of *E. affinis*.

Male.—The male is slenderer than the female, and the last cephalothoracic segment is rounded and not expanded into lateral wings. Plate 6, Figure 4, shows the male abdomen, and Figures 6 and 7 the fifth feet of the male.

Length: Sars stated that the female reaches 1.15 mm. Nordquist's figures made the male larger than the female, obviously a mistake. According to Esterly, the female is 1.56 mm and the male 1.15 mm. DeLint (1922), who made a detailed comparison of *E. affinis* and *E. hirundoides*, considered *E. hirundoides* much the smaller form.

Occurrence.—Nordquist's description was from material collected on the coast of Finland. Sars found it abundant on the coast of Norway. Van Breemen (1908) and DeLint (1922) reported it in Holland waters. In American waters Williams (1906) reported it in Narragansett Bay; Sharpe (1910) and Wilson (1932) at Woods Hole; Willey (1923) from Labrador and Nova Scotia; Esterly (1924) from San Francisco Bay; and Campbell (1929) from Vancouver Island. The author found it in Big Timber Creek, Gloucester, N. J., on September 19. Big Timber Creek is connected

with the Delaware River and is affected by the tides. With *E. hirundooides* were found some *Cyclops* species that are common in fresh water.

Remarks.—Nordquist noted that *E. hirundooides* is a form intermediate between *E. affinis* and *E. hirundo* and that in its variations it is connected with both species. Some authors have thought both *E. hirundo* and *E. hirundooides* should be considered as varieties of *E. affinis*. Inasmuch as the names cover distinct characteristics, it has seemed best here to give them specific rank, although it is recognized that they are closely related.

While *E. affinis* is found in both fresh and salt water, *E. hirundooides* apparently does not occur in water that is entirely fresh.

EURYTEMORA JOHANSENI Willey

PLATE 8, FIGURES 4, 7

Eurytemora johanseni WILLEY, 1920, p. 13K, figs. 5-7, 9, 11-13.

The wings of the last cephalothoracic segment are produced distad but do not reach the end of the first abdominal segment. (Pl. 8, fig. 4.) The first abdominal segment is expanded about midway of its length. The second and third segments and the furcal rami are of about equal length. The first antennae about equal the cephalothorax. In the fifth feet of the female (pl. 8, fig. 7) the unguiform process of the second segment of the exopod extends distad, but is not so long as the second segment; it is dentate on the inner border.

Length: Female, 1.28 mm; male, 1.12 mm.

Occurrence.—Described from collections of the Canadian Arctic expedition.

Genus EPISCHURA Forbes, 1882

Cephalothorax more or less distinctly 6-segmented. Abdomen in the female composed of four segments, in the male of five. Abdomen of the male more or less asymmetrical and in most species bent to the right; processes forming a prehensile apparatus projecting to the right; these processes, in *E. baikalensis* and *E. chankensis*, are found clearly only on the fifth segment, in the other species on the second, third, and fifth. The furcal rami are ciliate on the inner margin and each is armed with a short outer spine, a slender inner seta, and three plumose setae of about equal length.

The first antennae (pl. 9, fig. 1) are 25-segmented, the last segment short; the right male antenna (pl. 9, fig. 2) is 22-segmented, geniculate between the eighteenth and nineteenth segments, the segments preceding the geniculation being slightly swollen.

The exopod of the second antenna is 7-segmented, with three short central segments (pl. 11, fig. 1) and a short terminal segment. The

endopod of the maxilliped is 4-segmented (pl. 9, fig. 3). All the swimming feet are biramose, the exopods having three segments and the endopods one. In all the feet the endopods bear five setae. In the first foot the first and second segments of the exopods have each two setae, one external and one internal; the terminal segments bear six setae. In the second (pl. 9, fig. 5), third, and fourth feet the first and second segments of the exopods have spines externally instead of setae as in the first foot; the terminal segments have two short spines on the external border, at the end a long spine with its outer margin deeply serrate, and four setae on the inner border.

The fifth feet of the female (pl. 10, fig. 4) are uniramous. The first basipods are confluent; the second basipods are distinct; the exopod is 2-segmented, the second segment armed at the tip and sometimes on the sides with spines, which vary in number from three to eight; there are no endopods in mature forms.

The fifth feet of the male (pl. 9, fig. 4) are uniramous and dissimilar; the first basipods are confluent. The right foot consists of the second basipod and an exopod of one segment, the exopod being strongly flexed. The left foot consists of the second basipod and an exopod of two segments; the second basipod bears a long curved process projecting from its inner border; a study of larval forms shows that this process represents an endopod; the second segment of the exopod is more or less sinuate on the inner margin and, in all except *E. chankensis*, armed with spines; in *E. chankensis* there is a tuft of cilia at the tip.

Occurrence.—With the exception of two species, *E. baikalensis* and *E. chankensis*, which are found in Asia, the genus occurs only in North America. It is not commonly found much south of latitude 40° N. in America, and it extends north to Alaska. The three American species appear to have a fairly restricted distribution—*E. lacustris* to the general region of the Great Lakes, going north to Lake Winnipeg, *E. nevadensis* to the mountains of the Pacific region, from central California to Alaska, and *E. nordenskiöldi* to the Atlantic coast from Newfoundland to North Carolina.

KEY TO THE SPECIES OF EPISCHURA

- | | |
|--|-------------------------|
| 1. Segments 2, 3, and 5 of male abdomen armed with projecting processes----- | 2 |
| Only fifth abdominal segment of male armed with projecting processes----- | 4 |
| 2. Female abdomen bent to right, and external furcal setae much broader than others----- | <i>lacustris</i> Forbes |
| Female abdomen straight or nearly so, and all furcal setae approximately same width----- | 3 |

3. Fifth abdominal segment in male with two projecting processes;
terminal segment of female fifth foot armed with six spines.
nevadensis Lilljeborg
- Fifth abdominal segment in male with one projecting process;
terminal segment of female fifth foot armed with five spines.
nordenskiöldi Lilljeborg
4. Last thoracic segment of female expanded in large rounded
lobes; terminal segment of female fifth foot ending in a short
conical point and having three spines in its external border.
baikalensis Sars
- Last thoracic segment of female with shorter wings than in
baikalensis; terminal segment of female fifth foot armed with
three terminal spines.----- *chankensis* Rylov

EPISCHURA LACUSTRIS Forbes

PLATE 9; PLATE 10, FIGURES 3-5; PLATE 11, FIGURE 1

(?) *Scopiphora vagans* PICKERING, in DeKay, 1844, p. 62.

Epischura lacustris FORBES, 1882, pp. 541, 648, pl. 8, figs. 15, 16, 21, 23, pl. 9, fig. 8; 1891, p. 704, pl. 1, figs. 1-5, pl. 2, fig. 7.—HERRICK, 1884, p. 131, pl. Q, fig. 13.—DE GUERNE and RICHARD, 1889, p. 90, pl. 4, figs. 3, 9, 10.—MARSH, 1893, p. 200, pl. 4, fig. 6; 1895, p. 10, pl. 2, figs. 1-6, pl. 3, figs. 1-6; 1918, p. 756, fig. 1175.—HERRICK and TURNER, 1895, p. 82, pl. 13, fig. 15.—SCHACHT, 1898, p. 260.—TOLLINGER, 1911, p. 154, fig. 0¹.—WILSON, 1929, p. 126.

The abdomen of the female (pl. 10, fig. 5) is bent to the right. The first segment is short, the second about equal in length to the rest of the abdomen and the furca. The second segment is produced at the right in a rounded process. The spermatophore is ordinarily curved but not wound about the abdomen, as in *E. nordenskiöldi*. The furcal rami are broad. The spines at the external distal angles are stout, the right one being much broader than the left. Of the terminal setae, the outside ones are much broader than the others.

The 5-segmented abdomen of the male (pl. 10, fig. 3) is strongly bent to the right with processes projecting to the right from the second, third, and fifth segments. The process of the second segment is triangular, about as long as the segment is wide, with a rounded recurved tip; the distal border is sinuate and indistinctly toothed. The process of the third segment is similar in form and size to that of the second; it is armed at the tip with a rugose pad on both proximal and distal margins. From the right dorsal surface of the fifth segment there extends forward a smooth, spatulate process; from the ventral surface there extends to the right another similar process, which terminates in five to seven rather large teeth; its distal margin back from the tip is finely denticulate, the denticulations extending back to the furca; the spines of the furcal rami are not so prominent as in the female, and the furcal setae are of about equal width.

The antennae in the female (pl. 9, fig. 1) extend about to the fourth abdominal segment. The fifth feet of the female (pl. 10, fig. 4) are uniramous and 3-segmented, the first segment being the second basipod and the other two the exopod. The first segment is about as broad as long and bears a small spine at the outer distal angle. The segments of the exopod are elongate and narrower than the first. The second is about $1\frac{1}{3}$ times the length of the first. The first segment of the exopod has a spine at the outer distal angle. The terminal segment has 6 spines, 4 terminals and 1 on each side; 3 of the terminal spines are spinulose. In Plate 9, Figure 3, is shown the endopod of the maxilliped, and in Figure 5 the second swimming foot.

The right fifth foot of the male (pl. 9, fig. 4) is 2-segmented, consisting of the second basipod and a 1-segmented exopod, broad at the proximal end and diminishing to a blunt-pointed tip at the distal end; it is flexed upon the second basipod. The second basipod of the left fifth foot has a seta at three-fourths the length of the outer border; the second segment of the exopod has a broad base and terminates in a spine; its inner border is concave and armed with long hairs and it has on the outer border one to three spines.

Occurrence.—*E. lacustris* is found abundantly, especially in deep cool waters, in Illinois, Indiana, Ohio, Minnesota, Wisconsin, Michigan, and New York. It has been reported from Maine by Bishop and Clarke, and I have seen specimens collected in Lake Sebago by Doolittle. Willey (1920) reported it in Nova Scotia, Bigelow (1923) in Lake Nipigon, and Bajkov (1930) in Winnipeg, Winnipegosis, and Atikameg. De Guerne and Richard (1889) stated that it was found by Lilljeborg in a collection from East Portland, Oreg., and Schacht (1898) repeats this location; it seems probable that this identification was wrong and that Lilljeborg really had *E. nevadensis*, as there is no other report of *E. lacustris* in the Pacific coast region.

EPISCHURA NEVADENSIS Lilljeborg

PLATE 11, FIGURES 2-7; PLATE 12, FIGURE 1

- Epischura nevadensis* LILLJEBORG, in de Guerne and Richard, 1889, p. 93, pl. 2, figs. 17, 24, pl. 3, fig. 21.—HERRICK and TURNER, 1895, p. 84, pl. 11, figs. 1, 6, 8.—GIESBRECHT and SCHMELL, 1898, p. 183.—SCHACHT, 1898, p. 256.—TOLLINGER, 1911, pp. 153, 154, fig. N¹.—MARSH, 1918, p. 756, fig. 1174.
- Epischura nevadensis* var. *columbiae* FORBES, 1893, p. 254, pl. 41, figs. 19-21.—HERRICK and TURNER, 1895, p. 84, p. 11, figs. 4, 10.

The abdomen of the female (pl. 11, fig. 2) is straight or nearly so; the first and second and the third and fourth segments are ordinarily more or less confluent, so that the abdomen may appear to consist of less than four segments. The spermatophores are straight or slightly bent.

The spines at the external distal angles of the furca are not so broad as in *E. lacustris*, and the terminal setae are of equal width. The interior margins of the furca are finely ciliate.

The abdomen of the male (pl. 11, fig. 3) is strongly bent to the right. From the second abdominal segment a process extends to the right and is nearly as long as the width of the segment; it is recurved at the tip and both proximal and distal margins are sinuate and the distal margin is armed with irregular teeth. The process of the third segment extends to the right from the distal half of the segment, is of about the same width through its length, and is rounded at the end. There are two processes on the right of the fifth segment, one a rounded hyaline plate, somewhat spatula-shaped, and projecting forward from the dorsal surface to about the middle of the third segment, and the other (pl. 11, fig. 7) a somewhat triangular projection from the ventral surface to the right; this latter process bears five or six teeth, and extending down the dextral margin of the process are minute serrations, which, near the junction of the segment with the furca, are replaced by distinct teeth (pl. 11, fig. 7).

The first antennae of the female, according to Schacht, extend slightly beyond the third abdominal segment; according to Lilljeborg they do not reach the base of the furca. In the author's material the length is somewhat variable and in many cases exceeds that of the furca.

In the fifth foot of the female (pl. 11, fig. 4) the second basipod is longer than wide, the first and second segments of the exopod are of about equal length and not much narrower than the second basipod. The second basipod is armed on the outer border at about two-thirds or three-fourths of its length with a small spine or seta. The first segment of the exopod has, at its outer distal angle, a small spine. The second segment has six spines, one on each side and four terminal, the terminal being the larger. Forbes stated that a seventh spine is sometimes present on the third segment. Though six is the normal number, there is doubtless some variation in both number and position. Seven have been found in specimens from Alaska; in one preparation (pl. 11, fig. 5) eight were found, and in this the positions of the spines were different in the two feet.

The right fifth foot of the male (pl. 11, fig. 6) is 2-segmented. The first segment, which is really the second basipod, is more than twice as long as broad, wider at the distal end, and bears upon the inner distal margin a denticulate hyaline lamella. It has a delicate seta on the external margin at about two-thirds its length. The left foot does not differ from that in *E. lacustris*.

Length: According to Lilljeborg: Female, about 2 mm, male, about 1.7 mm; according to Schacht: Female, 2 mm to 2.5 mm, male, 1.7 mm to 2.1 mm. The author has made a number of measurements; of these the largest average was in collections from Hope, Idaho; the females measured 2.02 mm, the males 1.76 mm. In Tsiltcoos Lake, Oreg., the females averaged 1.32 mm and the males 1.27 mm.

Occurrence.—The original description was from material collected in Echo Lake and Lake Tahoe in California. Forbes found it in Swan Lake and Flathead Lake, Mont. Schacht also reported it from Gambles Lake and Lake Pend Oreille, Idaho; Lake Tahkenitch and Tsiltcoos Lake, Oreg.; and Lake Union and Lake Washington, Wash. Kemmerer, Bovard, and Boorman (1924) found it in many lakes in Washington and in Bear Lake, Idaho. It was found in collections made by E. M. Ball on Afognak Island, Alaska. T. L. Thacker has sent material from Lake Schkam and Kawakawa Lake, British Columbia, in which this species was found. The author found it in material collected by Dr. H. B. Ward, from a number of small lakes near Lake Tahoe, and has collected it in Stanislaus National Forest, Calif., and in Lake Chelan, Wash. An immature *Epischura* was found in Lake Helen on Mount Lassen, Calif., and in a pond at an elevation of 1,000 feet near Baldwin, Colo. It was impossible to identify this material but it probably would be this species. It will be seen that the distribution is pretty well limited to the Pacific region, the most eastern point being Bear Lake, Idaho, if we disregard the possible location in Colorado. It has not been found much south of the Lake Tahoe region but extends north into Alaska.

Remarks.—The original description by Lilljeborg is correct, but his figure of the male abdomen is misleading; from a certain angle it is correct as shown by the similar drawing from the ventral side. (Pl. 12, fig. 1.) Plate 11, Figure 3, however, gives a more accurate idea of its form. The figure by Forbes (1893) was in the main correct. Schacht stated that the appendage near the outer distal angle of the first segment of the female fifth foot is "correctly drawn by Lilljeborg as a seta, while Forbes's figure represents it as spine-like." This appendage seems to vary, sometimes being a seta and sometimes a spine. In material from Lake Tahoe it was a spine.

EPISCHURA NORDENSKIÖLDI Lilljeborg

PLATE 12, FIGURES 2-6

- Epischura nordenskiöldi* LILLJEBORG, in de Guerne and Richard, 1889, p. 146. pl. 1, fig. 36, pl. 2, figs. 15, 23.—HERRICK and TURNER, 1895, p. 85, pl. 11, figs. 2, 5, 9.—GIESBRECHT and SCHMEIL, 1898, p. 183.—SCHACHT, 1898, p. 252.—TOLLINGER, 1911, p. 153, fig. N⁴.—KIEFER, 1931, p. 583, figs. 1, 2.
Epischura nevadensis WILSON, 1932, pp. 115-117, fig. 77.

The abdomen of the female (pl. 12, fig. 3) is not bent. Of the four segments, the first two are frequently imperfectly separated. The furcal rami are about twice as long as broad and ciliate on the inner border. The spermatophore is bent around the abdomen, as shown in Plate 12, Figure 3.

The second, third, and fifth segments of the male abdomen (pl. 12, fig. 4) are armed with projecting processes. The process of the second segment is triangular, about one-half as long as the width of the segment, and rather strongly concave on the distal border. The process of the third segment is short and blunt and projects from the dextral distal angle of the segment. The process of the fifth segment is a small blunt pointed triangular hyaline plate on the right side projecting forward. A beadlike row of serrulations extends down the right side of the segment.

The female antennae are stated by Lilljeborg and by Schacht to reach the base of the furca; in the Massachusetts specimens they reached the end of the furca. In the fifth feet of the female (pl. 12, fig. 5) the second basipod is about as long as its width and bears near the outer distal angle a small spine or seta. The second basipod and the two segments of the exopod are of about equal length. The first segment of the exopod has a small spine at its outer distal angle. The second segment has five terminal spines, or they may be considered as three terminal and two lateral, one on each side.

The male fifth foot (pl. 12, fig. 6) is much like that in *E. lacustris* and *E. nevadensis*; there is a distinct difference, however, in the second segment of the exopod of the left foot; this is slightly curved, approximately of the same width throughout its length, blunt pointed, armed with four spines on its external border, and ciliate on the distal portion of the inner border. In some individuals the inner border of this segment is sinuate, in others it is an unbroken curve like the figure. Lilljeborg states that the second basipod of the left fifth foot bears a large hook on its inner border and shows this hook in his figure. Schacht (1898) also mentions this hook. The hook was not found in any of the Massachusetts material, and Schmeil (1898) stated that an examination of the original material of Lilljeborg failed to show its presence. Schacht's statement that he found the spine is evidently due to a misunderstanding. Schmeil wrote of the "thorn" on the *second basipod of the right foot*. This would be the segment commonly spoken of as the first, which Schacht refers to the *second*, or first segment of the exopod.

Length: According to Lilljeborg: Female, 2.9 mm, male, 1.1 mm; according to Schacht: Female, 1.9 mm, male, 1.1 mm. The Massachu-

setts specimens averaged: Female, 1.64 mm; male, 1.58 mm. It seems probable that Lilljeborg's figure for the female is a misprint for 1.9 mm.

Occurrence.—The original description was from collections made at St. Johns in Newfoundland. Schacht's description was from Lilljeborg's material. Willey (1923) reported it from the Shubenacadie River, Nova Scotia, but gave no description. Wilson collected it in eastern Massachusetts but determined it as *E. nevadensis*. An examination of his material deposited in the United States National Museum shows that it is *E. nordenskiöldi*. It seems probable that it will appear in other localities in New England. It was found in a collection made by Dr. R. E. Coker in White Lake, N. C.; this locality is especially interesting as it indicates a possible wide distribution of the species.

EPISCHURA BAIKALENSIS Sars

PLATE 13. FIGURES 1-4

Epischura baikalensis Sars, 1900, p. 226, pl. 6, figs. 1-17.—TOLLINGER, 1911, p. 157, fig. P⁴.—RYLOV, 1930, p. 258, fig. 84, 1 and 2; fig. 85, 1 and 2.

Female cephalic segment well defined, having dorsally a strongly marked cervical depression. Last cephalothoracic segment expanded on the sides in rather large rounded lobes. Abdomen (pl. 13, fig. 1) of three evident segments. The spermatophore is twisted and accompanied by a hyaline curved plate. The terminal setae of the furca in adult females are very short and curved.

The abdomen of the male (pl. 13, fig. 2) is asymmetrical, and the apical setae are of normal length. The abdomen is slightly bent to the right. The segments are of about equal length and more prominent on the right side. Only the last segment has a distinct process; this is a recurved lobule placed somewhat ventrally and projecting to the right.

The first antennae reach to about the end of the furca. The exopod of the second antenna is said by Sars to have five segments; his figure, however, more or less clearly shows six. Evidently Sars did not recognize the small terminal segment, which is characteristic of other species.

In the fifth feet of the female (pl. 13, fig. 3) the second basipod is short, about as broad as long, and armed with a small spinule on the external border. The first segment of the exopod has a spine at the outer distal angle. The second segment terminates in a short conical point and has three spines on its external border.

The right fifth foot of the male (pl. 13, fig. 4) is 2-segmented. The second basipod has a blunt projection from its inner border, probably representing an endopod; the exopod is a slender curved

hook. The second basipod of the left foot has the long curved projection of the genus, but it is longer and slenderer than in the other species. The first segment of the exopod is longer and narrower than the second basipod. The second segment of the exopod has a broad rounded end armed with two small spines.

Length: Female, 1.5 mm; male, 1.2 mm.

Found in Lake Baikal, Asia.

The preceding description is from the original account by Sars.

EPISCHURA CHANKENSIS Rylov

PLATE 10, FIGURES 1, 2

Epischura chankensis RYLOV, 1928, p. 126, figs. 1-12; 1930, p. 260, fig. 86, 1-3; fig. 87, 1 and 2; fig. 88, 1-4.

E. chankensis resembles *E. baikalensis* very closely but differs in the following particulars:

In the female the lateral wings of the last cephalothoracic segment are shorter and do not so distinctly project backward. The branches of the furca are asymmetric. The hyaline abdominal plate is larger than in *E. baikalensis*. The last segment of the exopod of the fifth foot (pl. 10, fig. 2) is shorter than in *E. baikalensis* and is armed with three rather stout spines, which are practically terminal.

In the right fifth foot of the male (pl. 10, fig. 1) the internal process of the second basipod is much longer than in *E. baikalensis*, and the hook of the terminal segment is irregularly curved. The terminal segment of the left foot is shorter than in *E. baikalensis* and armed at the end with a bunch of cilia.

Occurrence.—This species was found in Lake Chanka, about 200 kilometers north of Vladivostok.

DOUBTFUL SPECIES

EPISCHURA FLUVIATILIS Herrick, 1883

This species was reported by Herrick and has not been seen since. If his figures are correct, it is not an *Epischura*, and the suggestion of a new genus, *Lamellipodia*, by Schmeil is justified. As there are inconsistencies in Herrick's description, however, and as the form has been found by no one else, it seems better to consider this a doubtful species. Schacht has given a very full discussion of the subject, and it does not seem necessary to repeat it here.

EPISCHURA MASSACHUSETTENSIS Pearse, 1906

It is impossible to decide whether this is a new species or an imperfect description of one of those already recognized. Only females were found and the figures were of the abdomen and fifth foot. The

furca is armed with an external seta instead of a spine as in the American species of *Epischura*. The fifth foot has seven spines instead of five or six as in typical species. From the locality of Pearse's collection it would seem probable that he had *E. nordenskiöldi*, but the structure of the fifth foot would seem to negative this opinion.

Genus HETEROCOPE Sars, 1863

Heterocope closely resembles *Epischura*. While the form and segmentation of the cephalothorax are like *Epischura*, the abdomen of the female is 3-segmented and that of the male 5-segmented; the abdomen is not flexed in either sex. The furca, as in *Epischura*, is armed with three setae, but the external spine of *Epischura* is either lacking entirely or replaced by a short seta. The first and second antennae, mandibles, maxillae, and maxillipeds are like those in *Epischura*. The segmentation of the swimming feet is like that in *Epischura*, but in some species the armature of spines is developed asymmetrically.

In the fifth foot of the female the terminal segment is armed with two spines externally, with four hooklike teeth internally, and a long terminal claw. *Heterocope caspia* has only three internal spines and the terminal claw is simply a longer spine.

The right fifth foot of the male has a 2-segmented exopod (one in *H. caspia* and *H. appendiculata*), which is not reflexed as in *Epischura*. The terminal segment of the left foot has two lateral spines on the external border and two terminal spines, one of which is ordinarily elongated.

As material was not available for a critical study of any of the species of Europe and Asia, it did not seem wise, in this publication, to make a detailed analysis of the species. Only one species has been found in America and that is clearly distinct from those of the eastern continents.

H. caspia is very different from the other species, and it is possible that this should be considered as generically distinct. On this account it has seemed best to add a brief description of this species.

KEY TO THE SPECIES OF HETEROCOPE

1. Terminal segment of female fifth foot armed with six nearly equal spines----- *caspia* Sars
- Terminal segment of female fifth foot armed with six spines, four internal and two external, and an elongated terminal hook----- 2
2. Exopod of male right fifth foot united with second segment of basipod in a long curved single segment----- *appendiculata* Sars
- Exopod of male right fifth foot composed of one or two segments----- 3

3. Exopod of male right fifth foot composed of one segment— *soldatovi* Rylov
 Exopod of male right fifth foot composed of two segments..... 4
4. In female no processes on sides of genital opening; in male armature of swimming feet symmetrical..... *saliens* Lilljeborg¹⁹
 In female processes on sides of genital opening; in male armature of some of swimming feet symmetrical..... 5
5. In female a dentiform projection on each side of genital area; in male exopods of swimming feet 2 to 4 modified..... *borealis* Fischer¹¹
 In female trilobate processes on each side of genital opening; in male first, third, and fourth swimming feet symmetrical, exopod of right second foot much modified.
septentrionalis Juday and Muttkowski

HETEROCOPE SEPTENTRIONALIS Juday and Muttkowski

PLATE 14, FIGURES 1-8

Heterocope septentrionalis JUDAY and MUTTKOWSKI, 1915, pp. 27-31, figs. 4-6.—
 MARSH, 1920, pp. 5, 6, pl. 2, figs. 3, 5, 6, 8-13.—RYLOV, 1924, pp. 225-232.

The abdomen of the female (pl. 14, fig. 3) consists of three segments, the first being nearly equal to the combined length of the second and third; the second and third are of about the same length. The genital area bears two trilobate processes (pl. 14, figs. 5-7). Though these are typically trilobate, there is much variability in their form and sometimes they may be bilobate, as in Figure 7. The length of the furcal rami is about $1\frac{1}{2}$ times the breadth. They are ciliate on the inner border, and in addition to the three setae, typical of the genus, bear at the inner and outer distal angles short and slender setae.

The first antennae may slightly exceed the first abdominal segment. The second antennae are like those typical of *Heterocope*, the exopod consisting of seven segments, three short central and one short terminal.

The swimming feet are symmetrical. The fifth foot of the female (pl. 14, fig. 8) is like those typical of the genus. The second basipod and the first exopod are armed with spines at the outer distal angles. The second exopod bears two spines externally, a terminal claw which exceeds in length the segment, and in the inner border four hooklike teeth; these teeth are each armed with one to three denticles. There is a minute spine between the distal external spine and the terminal claw.

In the male the first, third, and fourth swimming feet are symmetrical. The right exopod of the second foot is quite different from the left (pl. 14, fig. 2); the spine of the first segment (pl. 14, fig. 4) is much enlarged and armed with denticles, which are more irregu-

¹⁹ Synonyms: *H. romana* Imhof, *H. robusta* Sars, *H. alpina* Sars.

¹¹ Synonyms: *H. robusta* Grube, *H. soliens* Nordquist, *H. weismanni* Imhof.

larly arranged than in the corresponding spines of the left side. The external spines of the second and third segments are elongated, more or less sigmoid in form, and not armed with serrations or denticulations.

In the fifth foot of the male (pl. 14, fig. 1) the second basipod of the right foot bears a small spine near the external distal angle; the exopod consists of two segments, the distal being rounded at the tip. In the left fifth foot the process of the second basipod is long and slender, gradually tapering toward the distal end.

Average length of female, 4 mm; of male, 3.85 mm.

Occurrence.—This species was first described from material collected on St. Paul Island, Alaska. It has been found also in collections made by Dr. Frits Johansen on Herschel Island off the coast of Yukon and in collections in tundra lakes made in the same general neighborhood by J. M. Jessup.

HETEROCOPE CASPIA Sars

Heterocope caspia Sars, 1897, pp. 50–55, pl. 5, figs. 1–15.—BREHM, 1911, p. 487.—FADEEW, 1926, p. 9, figs. 10–12.—RYLOV, 1930, pp. 254–256, fig. 83, 1–7.

In the female fifth foot the first basipods are not confluent, and the last segment of the exopod does not bear a long spine, but resembles the corresponding segment of the female fifth foot of *Epischura*.

The exopod of the right fifth foot of the male is 1-segmented and has a lobular external border. On the distal end of the terminal segment of the left exopod are three small spines. The process of the second basipod of the left foot is somewhat spatulate in form.

The exopod of the second antenna has seven segments, the first, third, fourth, fifth, and sixth being short; this segmentation is like that of *Diaptomus* rather than of typical *Heterocope*.

Length: Female, less than 2 mm; male, 1.5 mm.

H. caspia differs quite materially from typical *Heterocope*.

Occurrence.—Found in the basin of the Caspian Sea in both fresh and salt water. It is considered by some to belong to the *fauna relicta*.

Family PSEUDODIAPTOMIDAE

Genus PSEUDODIAPTOMUS Herrick, 1884

Pseudodiaptomus HERRICK, 1884, pp. 180, 181.

Heterocalanus T. SCOTT, 1893, pp. 39–41.

Weismanella DAHL, 1894, pp. 10, 11.

No available synopsis of the species commonly assigned to the genus *Pseudodiaptomus* has been made since 1898, when Giesbrecht and Schmeil published "Copepoda, Gymnoplea" in *Das Tierreich*. At that time there were nine recognized species. Now there are 24.

An attempt has been made herein to provide a synopsis that would make it possible to separate the species without necessarily referring to the original descriptions.

The treatment of *Pseudodiaptomus* in the present paper must be recognized as a preliminary study. Much of the published material is very imperfect and possibly contains many mistakes. Thirteen of the species have been described only once. *Pseudodiaptomus pelagicus* Herrick, which is the type of the genus and was described in 1884, has not been seen since that time; inasmuch as Herrick's figures were poor and his description brief, it leaves a little doubt as to the generic characteristics, to say nothing of the specific distinctions.

Unfortunately, the writer has had material of only part of the species. It is very desirable that the genus should be monographed after a thorough study of material of all the species. As this is not likely to be done for a long time, this preliminary synopsis may be of value.

Description.—Last two thoracic segments coalescent. The female abdomen is composed of three or four segments; in most cases of four. The first antennae are composed of 20 to 22 segments; the terminal portion of the right antenna of the male is composed of two segments, three in *P. hickmani*.

The exopod of the second antenna is composed, according to various authors, of two to seven segments. Herrick, in his original figure, shows three. Most authors state four. The structure is seen in Plate 15, Figure 5; Plate 16, Figure 4; Plate 17, Figure 3; and Plate 18, Figure 3; the first segment is short, the second long, followed by two or more imperfectly separated segments and then a segment about equal in length to the second. It is these short central segments that have caused the differences of opinion. Herrick does not recognize them at all. Cleve figures four in *aurivilli*, making a total of seven. Apparently in *coronatus* there may be distinguished more or less clearly three segments. The first four swimming feet are biramous, each ramus consisting of three segments.

The fifth feet of the female have no endopods; in *P. hessei* and *P. stuhlmanni* there are swellings of the inner margin of the second segment of the basipod which, perhaps, are indications of a rudimentary endopod. The exopod consists of two segments; Giesbrecht and Schmeil (1898) give "two or three segments." There is, in some species, an apparent separation of a third segment, but a study of the genus indicates that this is a modification of the form of the terminal hook. The typical armature of the terminal segment is a hook with a spine branching from its base and an inner and outer spine. These spines vary in length and form.

In the right fifth foot of the male the endopod may be rudimentary or lacking; the exopod has two or three segments with a terminal hook. In the left foot the endopod may be present or lacking; the exopod is 2- or 3-segmented.

Some of the species are reported as having two egg sacs and some as having only one. It is known that in *P. coronatus*, *culebrensis*, and *richardi*, although there are two sacs, only the left is fully developed, the right one being aborted. It seems probable that in the species reported with one sac this may be considered as the left, and possibly a more careful study may show indications of the right one.

Occurrence.—The genus *Pseudodiaptomus* has not been reported from European waters. Seven species occur in America, all but one, *P. culebrensis*, from waters connected with the Atlantic. Three are in South America in the Amazon or La Plata. Two are found in North America, *P. coronatus* on the New England coast and in Chesapeake Bay, and *P. pelagicus* in Mississippi Sound. *P. pelagicus*, which was described as the type of the genus by Herrick in 1884, has never been collected by anyone else. Two species were found in the Canal Zone. Species of *Pseudodiaptomus* have been found on both coasts of Africa, in the Red Sea, the Indian Ocean, Burma, and the East Indies.

KEY TO THE SPECIES OF PSEUDODIAPTOMUS

- | | |
|---|-------------------------------|
| 1. No endopods on male fifth foot..... | 2 |
| Endopods on both male fifth feet..... | 3 |
| Endopods on right male fifth foot only..... | aurivilli Cleve ¹² |
| Endopods on left male fifth foot only..... | 6 |
| 2. Last thoracic segment of female rounded; a long falciform hook
terminating second segment of exopod of fifth foot, nearly as
long as exopod..... | gracilis (Dahl) |
| Last thoracic segment of female with pointed wings; second
segment of exopod of fifth foot terminated by two broad,
nearly equal spines, which are about one-half as long as
exopod..... | clevei A. Scott |
| 3. Last thoracic segment in female rounded..... | hessei (Mrázek) |
| Last thoracic segment in female with pointed wings..... | 4 |
| 4. Right endopod of male fifth foot not bifid..... | stuhlmanni (Poppe and Mrázek) |
| Right endopod of male fifth foot bifid..... | 5 |
| 5. Terminal hook of female fifth foot and inner spine equal in
length; second segment of left exopod of male fifth foot trun-
cated at distal end..... | hickmani Sewell |
| Terminal hook of female fifth foot longer than inner spine;
second segment of exopod of male fifth foot pointed at distal
end..... | salinus (Giesbrecht) |
| 6. Left exopod of male fifth foot 1-segmented..... | acutus (Dahl) |
| Left exopod of male fifth foot 2-segmented..... | 7 |

¹² Synonym: *P. mertoni* Früchtl.

7. Terminal segment of left exopod of male fifth foot truncated----- 8
 Terminal segment of left exopod of male fifth foot either
 rounded or armed with a number of spines----- 9
8. Terminal segment of left exopod of male fifth foot dentate at
 distal margin and having an acute spine at inner distal angle.
richardi (Dahl)
- Terminal segment of left leg exopod of male fifth foot setose on
 distal margin and armed with a short, stout spine at inner
 distal angle----- cristobalensis Marsh
9. Terminal segment of left exopod of male fifth foot rounded at
 distal end----- culebrensis Marsh
- Terminal segment of left exopod of male fifth foot armed
 with spines----- 10
10. Left endopod nearly as long as exopod; abdomen of female
 4-segmented----- coronatus Williams
- Left endopod only slightly longer than first segment of exopod;
 abdomen of female 3-segmented----- pelagicus Herrick

PSEUDODIAPTOMUS ACUTUS (Dahl)

PLATE 15, FIGURES 1, 2, 4

Weismanella acuta DAHL, 1894, pp. 10, 11, pl. 1, figs. 9-11.

Pseudodiaptomus acutus GIESBRECHT and SCHMEL, 1898, p. 64.

Female.—The head is not distinctly separated from the thorax. The last two thoracic segments are armed, on the posterior border, with small spines, and the wings of the last segment are pointed. (Pl. 15, fig. 1.) There are spines on the posterior borders of the first three abdominal segments. The abdomen has four segments. The first antennae have 21 segments and extend to the second abdominal segment. In the fifth feet (pl. 15, fig. 4) the terminal hook is about twice as long as the third segment of the exopod. The inner spine of the second segment of the exopod is broad and ciliate.

Length, 1.3 mm.

Male.—In the fifth feet (pl. 15, fig. 2) there is a small endopod on the left foot. The terminal segment of the left foot is short and dentate on its distal border. The second segment of the basipod of the right foot has hairs along its inner border. The first segment of the exopod of the right foot has a linguiform appendage on its inner distal border.

Length, 1 mm.

Occurrence.—Found in the mouth of the Amazon in brackish water.

PSEUDODIAPTOMUS AURIVILLI Cleve

PLATE 15, FIGURES 3, 5-7

Pseudodiaptomus aurivilli CLEVE, 1901, pp. 48-50, pl. 6, figs. 11-22.—THOMPSON and SCOTT, 1903, p. 248, pl. 2, figs. 24-26.—A. SCOTT, 1909, p. 116.—SEWELL, 1912, p. 363.

Pseudodiaptomus mertoni FRÜCHTL, 1923, p. 455, figs. 23, 24.

Female.—Head and thorax united. Rostrum bifid, with long filaments. The last thoracic segment terminates in lateral spines. (Pl. 15, fig. 3.) The abdomen consists of four segments; there are spines on the distal margins of the first three segments. The furcal rami are seven or eight times as long as broad. The first antennae consist of 20 segments and extend to the second abdominal segment. The exopod of the second antenna is 7-segmented. (Pl. 15, fig. 5.) In the fifth foot (pl. 15, fig. 7) the first segment of the exopod is elongated. The second segment of the exopod, according to Cleve, terminates in three plumose setae, the central being about twice as long as the inner; Thompson and Scott figure one elongated seta and three spines.

Length, 1.2 mm.

Male.—The right fifth foot (pl. 15, fig. 6) has a short endopod armed with three spines. From the first segment of the right basipod, the second basipod, and the first exopod there are elongated linguiform projections; the one from the first segment of the exopod exceeds in length the second segment. The terminal hook is rather short and falciform. The left fifth foot has no endopod. The first segment of the exopod has a long, slender spine at its outer distal angle. The second segment is oval in outline and has a lateral spine at about one-third of its length.

Occurrence.—Found in Malay Archipelago, Indian Ocean, Dutch East Indies, and Bay of Bengal under marine conditions.

PSEUDODIAPTOMUS CLEVEI A. Scott

PLATE 16, FIGURES 1, 2

Pseudodiaptomus clevei A. SCOTT, 1909, pp. 116, 117, pl. 37, figs. 1-8.

Female.—The wings of the last thoracic segment are pointed; there are two dorsal spines in the surface of this segment. The abdomen has four segments; there are spines on the distal margins of the first, second, and third segments. The first antennae have 21 segments and extend to the fourth abdominal segment. In the fifth foot (pl. 16, fig. 1) there are two spines at the inner distal angle of the second segment of the basipod. The second segment of the exopod has an acute spine at the outer distal angle, a terminal spine or hook which has a broad spine near its base, and a broad inner spine which is nearly as long as the terminal central spine.

Length, 1.75 mm.

Male.—The fifth foot (pl. 16, fig. 2) has no endopods. The lateral spine of the second segment of the exopod of the right foot is long and slender, reaching the end of the terminal hook. The second segment of the exopod of the left foot is oval in outline, the end

being flattened and has a spine on the outer margin and two smaller ones on the end.

Length, 1.52 mm.

Occurrence.—Found in Dutch East Indies at Kangeang and Aru Islands in salt water.

PSEUDODIAPTOMUS CORONATUS Williams

PLATE 16, FIGURES 3-6

Pseudodiaptomus coronatus WILLIAMS, 1906, pp. 641-644, figs. 1-7.—WILSON, 1932, pp. 101-103, fig. 68.

Female.—The last thoracic segment is rounded. The abdomen (pl. 16, fig. 3) consists of four segments, the second and third ordinarily imperfectly separated. The first abdominal segment has rows of small spines on the dorsal surface at about one-half its length and spines on the distal margin; it is enlarged in front and has a pair of linguiform flaps over the genital aperture. The length of the furcal rami is about eight times their width; they are ciliate on both inner and outer margins. There are two egg sacs, but the right is aborted, containing commonly only two ova; sometimes the right is entirely lacking. The first antennae are composed of 22 segments and about equal in length the cephalothorax. The exopod of the second antennae is apparently 6-segmented. (Pl. 16, fig. 4.) In the fifth foot (pl. 16, fig. 5) the distal margins of the second segment of the basipod and the first segment of the exopod are armed with small spines. There is a spine at the exterior distal angle of the first segment of the exopod. The second segment of the exopod terminates in a rather long curved hook; there is a spine at the outer distal angle and, near the inner angle, a broad plumose spine. A small spine is attached to the base of the hook. The first segment of the exopod is more than twice as long as the second.

Length, 1.5 mm.

Male.—There is an endopod (pl. 16, fig. 6) on the left fifth foot. The first segment of the basipod of the right foot is extended on the inner distal angle into a stout spine reaching about one-half the length of the second segment of the basipod; its inner border has a short spine. The first segment of the right exopod has a stout blunt spine projecting from its dorsal surface; this spine is three-fourths as long as the segment. The inner border of the segment has short spines like those on the second segment of the basipod and near the proximal end a flask-shaped spine; this spine seems to be constant in the species. Dahl figures a similar spine in *P. richardi*. The second segment of the exopod has an acute external spine at about three-fourths of its length. The terminal hook is nearly

as long as the two segments of the exopod; on its inner border, near the base, is an acute spine. The first segment of the basipod of the left foot has four slender acute spines on its inner border. The second segment of the basipod has short spines along its inner border. The first segment of the exopod is short, with an acute spine at its outer distal border. The second segment of the exopod is about twice the length of the first, and is pointed at the end where there are three acute spines.

Length, 1.2 mm.

Occurrence.—It has been found in Narragansett Bay, Charlestown Pond at Woods Hole, and in Chesapeake Bay. Willey has reported it in Miramichi Estuary and Minas Basin. It occurs in salt and brackish water.

PSEUDODIAPTOMUS CRISTOBALENSIS Marsh

PLATE 16, FIGURE 7; PLATE 17, FIGURES 1-3

Pseudodiaptomus cristobalensis MARSH, 1913, pp. 6-8, pl. 2, figs. 1-3.

The female of this species is unknown.

The head and the first thoracic segment are coalescent. The last thoracic segment is terminated on each side with a somewhat prominent spine (pl. 17, fig. 1). The first three abdominal segments (pl. 17, fig. 2) have spines on the distal borders. The first antennae are composed of 22 segments and about equal in length the cephalothorax. The exopods of the second antennae (pl. 17, fig. 3) show clearly only two segments in the central portion. In the fifth feet (pl. 16, fig. 7) the right foot has no endopod. The hook of the right exopod is stout and about equal in length to the second segment. The left foot has a spatulate endopod, which is about twice as long as the first segment of the exopod. The second segment of the exopod is truncate at its distal end, which is armed with minute setae, has a spine about midway of the outer margin, and a minute spine opposite on the inner margin. There is a stout spine on the inner margin at about three-fourths its length and another at the inner distal angle.

Length, 0.1 mm.

Occurrence.—Found in the old French canal on the Atlantic side of the Isthmus of Panama.

PSEUDODIAPTOMUS CULEBRENSIS Marsh

PLATE 17, FIGURES 4-6; PLATE 18, FIGURES 1-3

Pseudodiaptomus culebrensis MARSH, 1913, pp. 4-6, pl. 1, figs. 1-7.

Female.—The head (pl. 18, fig. 1) is broadly rounded; the dorsal surface of the last two segments of the thorax is armed with hairs.

The angles of the last thoracic segment are rounded and hairy. The abdomen (pl. 17, fig. 6) is 3-segmented; the first segment is not expanded laterally. There are hairs on the left lateral margin of the third segment. The furcal rami are asymmetric, about seven times as long as wide and ciliate on the inner margins. The antennae are 22-segmented and exceed the cephalothorax. The segmentation of the exopod of the second antenna was indistinct in the material examined. In Plate 18, Figure 3, two central segments are shown. In others only one can be distinguished. In the fifth feet (pl. 17, fig. 5) the distal margin of the second segment of the basipod has a row of spines, and at about one-third of the length of the segment is a small lateral hair. The first segment of the exopod is about three times the length of the second. Both segments of the exopod have slender acute spines at the outer distal angles. The second segment has also two spines at the inner distal angle, one short, the other longer and ciliated. The terminal hook is slender and acute with a short blunt spine on the inner margin of the base.

In all specimens examined the right egg sac was atrophied; the left contained about eight ova.

Length, 1.22 mm.

Male.—The abdomen (pl. 18, fig. 2) is 5-segmented, the second, third, and fourth segments having spines on the distal margins. The furcal rami are short, the length being two or three times the width, and the inner borders are ciliate. The first basal segments of the fifth foot (pl. 17, fig. 4) have acute spines on the posterior surfaces. The second basal segment of the right foot is much wider at the proximal end, on account of a projection from the inner margin; this projection is armed with long acute spines. A diagonal cuticular ridge on the posterior surface is armed on the proximal third with a row of acute slender spines. About midway of the posterior surface are two stout hairs. There are short hairs on the outer and distal margins. On the posterior surface of the first segment of the exopod of the right foot is a stout hair. From the dorsal surface near the distal end projects a stout blunt process which is about one-half as long as the segment. There is a long hair at the middle of the inner border and short spines at the inner distal angle. The lateral spine of the second segment of the exopod is situated at about the middle of the outer margin, is straight, about as long as the first exopod, and is denticulate on the margins. The terminal hook is falciform, denticulate on the inner margin, and has two short hairs on its base. There is no endopod on the right foot. The second basal segment on the left fifth foot of the male has long acute spines

on its inner margin and a hair on the posterior surface near the inner distal angle. The second segment of the exopod is about equal in length to the first, is curved, its outer margin being convex and its inner concave, and is armed with three blunt spines. The endopod is elongate, of one segment, rounded at the distal end and longer than the first segment of the exopod.

Length, 0.88 mm.

Occurrence.—Found in Rio Culebra, a branch of the Rio Chepo in Panama. Dodds (1926) reported it from Miraflores Lake. This is the only species of *Pseudodiaptomus* that has been found on the Pacific coast of America.

PSEUDODIAPTOMUS GRACILIS (Dahl)

PLATE 18, FIGURES 4-6

Weismanella gracilis DAHL, 1894, p. 11, pl. 1, figs. 12-14.

Pseudodiaptomus gracilis GIESBRECHT and SCHMEIL, 1898, p. 65.—WRIGHT, 1928, pp. 589-592, figs. 1, 2.

Female.—Head and thorax not clearly separated. Last thoracic segment rounded, without spines. The abdomen (pl. 18, fig. 6) consists of four segments. There are processes on each side of the genital aperture. There are spines on the distal margins of the first three segments. The furcal rami are rather short, about four times as long as broad, and ciliate on the inner margins. The first antennae have 20 to 22 segments. Dahl figures 20, and Giesbrecht and Schmeil give the same number; Wright gives 22; the author has found sometimes 20 and sometimes 22. The antennae reach the end of the first abdominal segment. In the fifth feet (pl. 18, fig. 4) the two basal segments and the first exopod have minute spines on their distal borders. There is an acute spine at the outer distal angle of the second segment of the basipod and a rather stout curved spine at the similar position on the first segment. The second segment of the exopod has a strong spine about midway of its outer border. The terminal hook is slender, falciform, and finely dentate on its inner border. At its base is an acute, curved dentate spine; this is the typical inner spine of the genus. The usual spine branching from the base of the hook is, in this species, a slender acute spine applied closely to the hook. It is not shown in Figure 4.

Male.—The fifth foot of the male (pl. 18, fig. 5) has no endopods. The second segment of the basipod of the right foot has hairs on the inner border. The first segment of the exopod has long stiff hairs on its inner border and the outer distal angle is prolonged into a hooklike spine, which nearly reaches the end of the second segment. The second segment of the exopod has an acute spine at about two-

thirds the length of the inner border and a long slender spine at the outer distal angle. The terminal hook is falciform about as long as the exopod; there is a small spine on the inner border. The first segment of the basipod of the left foot has fine spines on its inner border. The second segment is longer than the corresponding segment of the right foot and has hairs on its inner border. The exopod is 3-segmented. The first segment is broader than long, has an acute spine at the inner distal angle, and a short, stout, curved spine at the outer distal angle. The second segment of the exopod is short, armed with spines on its distal margin. The third segment is oval, as long as the rest of the left foot; it has a single acute spine at its distal end.

Length: Dahl, female: 1 mm; male: 0.9 mm. Wright, female: 1.17 mm; male: 1 mm.

Occurrence.—Found in the mouth of the Amazon and as far up the river as Santarem.

Remarks.—Dahl figured a spine by the first antennae of the female, and Giesbrecht and Schmeil use this as a distinguishing characteristic of the genus. Wright stated that "the head bears a pointed process on either side." These spines were not seen in the material studied by the author, but it was noticed that the head has a bifid rostrum.

The form of the terminal segment of the left foot of the male is peculiar and appears in only one other species, *P. clevei*. It should be noticed, too, that the figure published here shows *three* segments in the left exopod of the male fifth foot. In Giesbrecht and Schmeil's synopsis it was stated that the exopods of the male fifth feet are *2-segmented*. Though Wright considered the left exopod 2-segmented, his figure apparently shows three segments. This is the only species in which this exopod consists of three segments.

PSEUDODIAPTOMUS HESSEI (Mrázek)

PLATE 19, FIGURES 1, 2

Schmackeria hessei MRÁZEK, 1894, pp. 1-3, figs. 1-3.

Pseudodiaptomus hessei GIESBRECHT and SCHMEIL, 1898, p. 65.

Female.—The last thoracic segment is rounded. The distal borders of the first three abdominal segments are armed with spines. The furcal rami are about three times as long as wide. The third furcal seta is broader than the others. The first antennae have 22 segments. In the fifth foot (pl. 19, fig. 1) there is a hyaline projection on the second segment of the basipod; the second segment of the exopod has a small acute spine at the outer distal angle, a large plu-

mose spine at the inner distal angle; the terminal spine is elongate, apparently with a hyaline lamella and has a rather long slender spine at its base.

Length, 1.2 mm.

Male.—The right fifth foot (pl. 19, fig. 2) has what may be a rudimentary endopod about midway of the inner border of the second segment of the basipod. The first segment of the exopod is extended at its outer distal angle into a hooklike projection which is about four-fifths as long as the second segment. The second segment of the exopod has a straight, slender, lateral spine near the distal end. The terminal hook is symmetrically curved and is about as long as the two segments of the exopod. The left foot has an irregularly shaped endopod, which reaches nearly to the middle of the second segment of the exopod. The second segment of the exopod is rather broadly expanded, has a spine about midway of the external margin, and has some surface hairs. The left foot reaches the base of the hook of the right foot.

Occurrence.—Found in Banana Creek at the mouth of the Congo.

PSEUDODIAPTOMUS HICKMANI Sewell

PLATE 19, FIGURES 3, 4

Pseudodiaptomus hickmani SEWELL, 1912, p. 364, pl. 22, figs. 1-7.

Female.—The head is separated from the thorax and is somewhat pointed in outline; it has a bifid rostrum. The sides of the last thoracic segment are pointed. The first three abdominal segments have spines on their distal borders. The furcal rami are short, about twice as long as broad, and ciliate on the inner margins. The antennae have 22 segments and nearly reach the second abdominal segment. The second segment of the exopod of the fifth foot (pl. 19, fig. 3) has a very small spine at the outer distal angle; it terminates in two stout spines of nearly equal length, the inner one bearing a dentate lamella. The spine representing the hook has a small blunt spine on its base.

Length, 1.37 mm.

Male.—The terminal portion of the right antenna has three segments. In the right fifth foot (pl. 19, fig. 4) the second segment of the basipod has a Y-shaped endopod, the two branches having bifid tips. The exopod has three segments. From the base of the first segment of the exopod springs a Y-shaped process. The second segment of the exopod has a row of small spines at its outer distal angle, and at the inner distal angle a stout serrate spine. The terminal hook is stout and denticulate. An endopod on the left foot reaches to more than half the length of the second segment of the exopod.

The first segment of the exopod is short with a spine at the outer distal angle; the second segment of the exopod is a flat plate, squarely truncate at the distal end; it has a spine at each distal angle and the distal margin is finely denticulated.

Length, 1.3 mm.

Occurrence.—Found in Burma.

PSEUDODIAPTOMUS PELAGICUS Herrick

PLATE 19, FIGURES 5, 6; PLATE 20, FIGURE 2

Pseudodiaptomus pelagicus HERRICK, 1884, p. 181; 1887, pp. 10, 11, pl. 1, fig. 8, pl. 2, figs. 1-8.—HERRICK and TURNER, 1895, p. 53, pl. 1, figs. 11-17.—GIESBRECHT and SCHMEIL, 1898, p. 64.

Female (pl. 19, fig. 5).—Head rounded, beaked, and separated from the thorax. The sides of the last thoracic segment are pointed. The abdomen has three segments. The furcal rami are elongated and have spines on the margins. The first antennae have 22 segments and extend to the furca. In the fifth feet (pl. 19, fig. 6) the first segment of the exopod is elongate, and has a spine at the inner distal angle and a group of small spines on the distal third of the inner margin. At distal end of the second segment of the exopod there is an external spine and a stout internal spine. The terminal hook is falciform, dentate on the inner border, and much longer than the second segment of the exopod. Ovisac single.

Male.—In the male fifth foot (pl. 20, fig. 2) the second segments of the basipods are armed, on the inner borders, with a mass of rather coarse spines. The first segment of the exopod of the right foot has a row of spines on its inner border and two rather long spines, one near the proximal end and the other at the inner distal angle. The lateral spine of the second segment of the right exopod is situated at about three-fourths the length of the segment. The terminal hook is about as long as the two segments of the exopod. The second segment of the basipod of the left foot has, besides the spines of the inner border, four spines on the outer border. There is a spinelike endopod that exceeds the length of the first segment of the exopod. The first segment of the exopod has a slender spine at its outer distal angle. The second segment is twice as long as the first and terminated by four spines.

Occurrence.—Found in Mississippi Sound.

Remarks.—The description is from the statements and figures of Herrick. No other collections of the species have been reported. The figures are taken from Herrick; while they are diagnostically sufficient, there is some question of their accuracy, especially of those of the fifth feet.

PSEUDODIAPTOMUS RICHARDI (Dahl)

PLATE 20, FIGURES 1, 3

Weismanella richardi DAHL, 1894, p. 11, pl. 1, figs. 6-8.

Schmackeria richardi POPPE and MRÁZEK, 1895, p. 5.

Pseudodiaptomus richardi GIESBRECHT and SCHMEIL, 1898, p. 64.—MRÁZEK, 1901, p. 14, figs. 14, 29.—PESTA, 1927, p. 71, fig. 2, *b-d*.

Pseudodiaptomus richardi var. *inaequalis* BRIAN, 1926, pp. 187, 188, figs. 15, 16.

Female.—The head is not directly separated from the thorax. The sides of the last thoracic segment are rounded. The abdomen has four segments and the distal borders of the segments do not have spines. The furcal rami are short. The first antennae have 20 (21 according to Brian) segments and reach the second abdominal segment. The fifth feet (pl. 20, fig. 3) are much like those of *P. pelagicus* and *P. coronatus*, the terminal segment having, besides the hook, a small acute external spine, and a stout internal spine. The left egg sac is much more developed than the right, containing 10 to 12 ova, while the right has 4 or 5.

Length, 1.4 mm.

Male.—The right fifth foot (pl. 20, fig. 1) resembles closely that of *P. coronatus*, but does not have the stout spine that in *P. coronatus* is found on the first segment of the basipod. It has the flask-shaped spine on the first segment of the exopod which is found in *coronatus*; this is shown in Dahl's figure and in the figure of Brian's variety *inaequalis*. The left foot has an endopod extending to about one-half the length of the second segment of the exopod. The first segment of the exopod is short, the second about as long as broad. The second segment of the exopod is truncate at the distal end; the distal margin is dentate; there is a slender curved spine at the inner distal angle and at the base of this spine a short stout spine.

Length, 1 mm.

Occurrence.—Found in brackish water at the mouths of the Amazon, the La Plata, and the Parana Rivers.

Remarks.—*P. richardi* var. *inaequalis* Brian differs from the type in that the last thoracic segment of the female is prolonged backward into lobes, which are armed with spines.

PSEUDODIAPTOMUS SALINUS (Giesbrecht)

PLATE 20, FIGURES 4, 5

Schmackeria salina GIESBRECHT, 1896, pp. 322, 323, pl. 6, figs. 23-28.

Pseudodiaptomus salinus GIESBRECHT and SCHMEIL, 1898, p. 65.—THOMPSON and SCOTT, 1903, p. 248, pl. 2, figs. 21-23.

Female.—The head is not distinctly separated from the thorax. The wings of the last thoracic segment are pointed. The abdomen

has four segments; the third segment has spines on its distal border, but there are more on the other segments. The furcal rami are short. The terminal hook of the exopod of the fifth foot (pl. 20, fig. 4) is only slightly curved; in addition to the hook the terminal segment has a small external spine, a stout spine at the inner base of the hook, and an internal spine broadened by a dentate hyaline lamella.

Length, 1.25 mm.

Male.—There are endopods on both fifth feet. (Pl. 20, fig. 5.) The endopod of the right foot is bifid, one branch terminating in a spine and the other having short hairs. The first segment of the exopod has hairs on the inner distal margin and a long slender spine on the outer margin. The lateral spine of the second segment of the exopod is at the distal end. The terminal hook is serrate on the inner margin and in addition to the small spine on the inner margin of the base, has a curved spine on the outer margin. The endopod of the left foot is 1-segmented, slender, and extends about one-half the length of the second segment of the exopod. The first segment of the exopod is slightly longer than wide and has a long slender spine at the outer distal angle. The second segment of the exopod is expanded, the outer margin a regular curve, the inner sinuate, ending in a point directed inward. There are two external spines on this segment and one internal situated near the distal end.

Length, 1.25 mm.

Occurrence.—Found in Red Sea, Gulf of Suez, and Indian Ocean.

PSEUDODIAPTOMUS STUHLMANNI (Poppe and Mrázek)

PLATE 20, FIGURES 6, 7

Schmackeria stuhlmanni POPPE and MRÁZEK, 1895, pp. 6, 7, pl. 1, figs. 1-9.

Pseudodiaptomus stuhlmanni GIESBRECHT and SCHMEIL, 1898, pp. 65, 66, fig. 16.

Female.—The head is narrowly rounded. The wings of the last thoracic segment are pointed. The abdomen has four segments; there are spines on the distal borders of the first three segments. The furcal rami are rather short. The first antennae have 21 segments and do not reach the end of the first abdominal segment. In the fifth foot (pl. 20, fig. 6) the second segment of the basipod has a rounded projection on its inner margin; the second segment of the exopod has a small external spine, a rather short hook with a spine branching from its base and an internal spine, which has a narrow hyaline lamella.

Length, 1.4 mm.

Male.—On the inner margin of the first segment of the basipod of the right fifth foot (pl. 20, fig. 7) is a stout claw projecting inward; from this segment, too, is a slender spatulate endopod, which

reaches to about the end of the first segment of the exopod. The first segment of the exopod has patches of small spines on its posterior surface and the outer distal angle is extended in a spine which exceeds two-thirds the length of the second segment; the lateral spine of the second segment is near the distal end. The terminal hook is falciform and about as long as the two segments of the exopod. The left foot has a flask-shaped endopod, the base broad and the distal end pointed. The second segment of the exopod is broadened, pointed at the distal end, and has a spine on its outer border.

Length, 1.3 mm.

Occurrence.—Found in Quilimane River, East Africa.

Remarks.—*P. stuhlmanni*, *P. salinus*, and *P. hessei* are very closely related, but are clearly distinguished by details of the fifth feet of the male.

Genus SCHMACKERIA Poppe and Richard, 1890

From *Pseudodiaptomus* as generally recognized may be separated those species in which the second segment of the basipod of the left fifth foot of the male is armed, on its inner border, with a long curved projection resembling, in some cases, the similar structure in *Epischura*. In all these species the last thoracic segment of the female is rounded. In other respects they do not differ from the recognized diagnosis of *Pseudodiaptomus*. For these species the generic name *Schmackeria* is revived, as *S. forbesi* was one of these species and was made by Poppe and Richard the type of the genus *Schmackeria*.

Occurrence.—*Schmackeria* occurs in India, China, Celebes, the Philippines, and Africa; only one species, *S. serricaudatus*, is found in Africa.

Our knowledge of this genus as well as of *Pseudodiaptomus* is very incomplete, and a discussion of the causes of distribution and the genesis of the forms is impossible at the present time.

KEY TO THE SPECIES OF SCHMACKERIA

- 1. Two processes on second segment of basipod of left fifth foot of male..... 2
 One process on second segment of basipod of left fifth foot of male..... 4
- 2. Both processes springing from second basipod..... 3
 One process springing from basipod, the other a branch of the first..... *smithi* Wright
- 3. Process on second segment of basipod of right fifth foot of male with a spine and a lobular branch, corresponding to an endopod; female having a single spine on dorsal surface of last thoracic segment..... *tollingeri* (Sewell)

- No process on second segment of basipod of right fifth foot of male; in female two spines on dorsal surface of last thoracic segment ----- *poppei* (Stingelin)
4. An endopod on right fifth foot of male ----- 5
 No endopod on right fifth foot of male ----- 6
5. Process of second basipod of left fifth foot of male consisting of a broad blunt-pointed expansion of the segment ----- *annandalei* (Sewell)
 Process of second segment of basipod of left fifth foot of male long, slender, and sinuate ----- *serricaudatus* (T. Scott)
6. Process of second segment of basipod of left fifth foot of male having a broad spine on its dorsal border near the base, perhaps indicative of the 2-branched condition seen in *smithi*, *tollingeri*, and *poppei* ----- 7
 Process having no spine or indication of division ----- 8
7. All furcal setae of female of approximately same width; external spine of first segment of right exopod of male as long as second segment ----- *forbesi* Poppe and Richard
 Third furcal seta of female much broader than others; external spine of first segment of right exopod of male shorter than second segment ----- *inopinus* Burckhardt
8. In male process of second segment of basipod of left fifth foot pointed; in female third furcal seta broader than others. ----- *binghami* (Sewell)
 In male process of second segment of basipod of left fifth foot rounded; in female furcal setae of approximately equal width ----- *lobipes* (Gurney)

SCHMACKERIA ANNANDALEI (Sewell)

PLATE 20, FIGURE 8; PLATE 21, FIGURE 1

Pseudodiaptomus annandalei SEWELL, 1919, pp. 5-7, pl. 10, fig. 9; 1924, p. 787 pl. 44, fig. 2.

Female.—The head is fused with the first thoracic segment. The rostrum is bifid. The last thoracic segment is rounded and has on each side a comb of six to eight coarse teeth. The abdomen has four segments. The first segment is produced on each side into a large recurved spine. Segments 2 and 3 have spines on the distal borders. The furcal rami are short and ciliate on the inner borders. The third seta is much broader than the others. The first antennae have 21 segments and reach the second abdominal segment. In the fifth foot (pl. 21, fig. 1), according to Sewell's figure, it appears probable that the second segment of the exopod has a small outer spine, a hook with a long slender spine from its base, and a rather broad inner spine; it seems that the separation of the hook from the second segment of the exopod is not shown in the figure.

Length, 1.18 mm.

Male.—Sewell states that the male fifth foot consists of *three segments*, which he considers as belonging to the exopod. An examination of his figure (pl. 20, fig. 8), which, evidently, was imperfectly

drawn, makes it fairly certain that in this species, as in others of the genus, each foot consists of a 2-segmented basipod and a 2-segmented exopod. In the right foot the second segment of the basipod, not as stated by Sewell the *first* segment of the exopod, has a row of spines on its outer margin and from its inner margin a bifid process which is probably an endopod. The long spinelike process with the short recurved hook must be the long spine which is usually present on the outer distal angle of the first segment of the exopod. The separation between the first and second segments of the exopod is not shown in the figure. The terminal hook is broad. Using a similar interpretation in regard to the segments of the left foot, we may describe it as follows: The second segment of the basipod is expanded internally into a broad process, doubtless representing the endopod. The first segment of the exopod has a blunt process and a spine on its inner border. The second segment of the exopod has a stout dentate spine on its outer margin at about one-third the length of the segment; it terminates in a blunt point, which has, on the inner side, a blunt spine.

Length, 1.09 mm.

Occurrence.—Found in Chilka Lake, India.

SCHMACKERIA BINGHAMI (Sewell)

PLATE 21, FIGURES 2, 3

Pseudodiaptomus binghami SEWELL, 1912, pp. 337, 338, pl. 17, figs. 8–11; 1919, pp. 7–9; 1924, p. 786, pl. 45, fig. 2.

Female.—The head is fused with the first thoracic segment. The rostrum is bifid. The last thoracic segment is rounded and has a small spine near the dorsal surface. The abdomen has four segments, the first three having spines at the distal ends. The furcal rami are rather short and symmetrical, and are ciliate on the inner border. The third terminal seta is much broader than the others. The terminal segment of the fifth foot (pl. 21, fig. 3) has besides the terminal hook a small external spine, a stouter internal spine, and from the base of the hook a slender spine equaling in length the one at the inner angle.

Length, 1.3 mm.

Male.—In the right fifth foot (pl. 21, fig. 2) there is a prominent rounded process on the interior of the terminal hook about midway of its length. The process of the second segment of the basipod of the left foot is long, curved, and pointed. The second segment of the left exopod is a broad, oval plate having a spine about midway of its outer border and a row of small spines on the inner border near the proximal end.

Length, 0.86 mm.

Occurrence.—Found in India.

Remarks.—This species in many respects is almost identical with *S. lobipes* of Gurney. There are, however, minor differences in the fifth feet of both sexes, and the broad third furcal seta of *S. binghami* makes a definite difference.

SCHMACKERIA FORBESI Poppe and Richard

PLATE 21, FIGURES 4, 5, 7

Schmackeria forbesi POPPE and RICHARD, 1890, pp. 1-8, pl. 10, figs. 1-14.

Pseudodiaptomus forbesi GIESBRECHT and SCHMEIL, 1898, p. 66.—BURCKHARDT, 1913, pp. 379-394, pl. 11E, figs. 1-6, pl. 11F, figs. 5-8, pl. 11G, figs. 5-9, pl. 12H, figs. 5, 6, 9.—KIKUCHI, 1928, pp. 69, 70, pl. 19, figs. 19, 20.

Female.—The head and first thoracic segment are fused. The sides of the last thoracic segment are rounded and armed with hairs. The abdomen has four segments. The first three abdominal segments (pl. 21, fig. 7) have spines on their distal borders. The first antennae have 22 segments and extend to the second abdominal segment. The furcal rami are about four times as long as the width and are ciliate on the inner border. In the fifth foot (pl. 21, fig. 5) the two segments of the exopod are short; the first segment has a spine at the outer distal angle and a hyaline plate at the inner angle. The second segment has an external lateral spine, a terminal elongated hook, and a stout dentate internal spine.

Male.—In the fifth foot (pl. 21, fig. 4) the second segment of the right basipod has two tuberos projections on the inner border. The long external spine of the first segment of the exopod about equals the length of the second segment. The falciform terminal hook is about as long as the whole exopod. In the left foot the second segment of the exopod has from its inner border a long, slender, curved process projecting distal. This process has, from its base, a sharp branch about one-half as long as the second segment of the exopod. The second segment of the exopod is a bilobed plate.

Length: According to Poppe and Richard, female: 1.2 mm; male: 1.15 mm. According to Burckhardt, female: 1.35 mm; male: 1.12 mm.

Occurrence.—Found in China in the Yangtze Kiang and connecting waters.

SCHMACKERIA INOPINUS Burckhardt

PLATE 21, FIGURE 6; PLATE 22, FIGURE 1

Schmackeria inopinus BURCKHARDT, 1913, pp. 379-394, pl. 11E, figs. 2-5, pl. 11F, figs. 1-4, 9, 10; pl. 11G, figs. 1-4, 6-8, pl. 12H, figs. 1-4, 7, 8, 10, 11.

Pseudodiaptomus japonicus KIKUCHI, 1923, pp. 68-70, pl. 19, figs. 19, 20.

Pseudodiaptomus inopinus SMIENOV, 1929, pp. 318-320, figs. 1-3.

Schmackeria inopinus resembles *S. forbesi* so closely that it is somewhat difficult to separate them without examination of the

females. In the female furca (pl. 22, fig. 1) the third seta is much broader than the others. There is no difference in the female fifth feet. In the male fifth feet (pl. 21, fig. 6) the spine at the distal end of the first segment of the right exopod about equals the second segment in *forbesi*, but is shorter in *inopinus*. Burekhardt also makes the depression in the terminal segment of the left foot which separates the two lobes sharper in *forbesi* than in *inopinus*, stating that it is 30° or 40° as compared with 90° ; it is doubtful whether this distinction will hold.

If it were not for the difference in the furcal setae, one might be inclined to think of *inopinus* as simply a variety of *forbesi*. *S. inopinus* is somewhat smaller than *forbesi*.

Length: Female, 1.15 mm; male, 1.03 mm.

Occurrence.—Found in the Yangtze Kiang. It belongs more distinctly to the plankton than does *forbesi*.

SCHMACKERIA LOBIPES (Gurney)

PLATE 22, FIGURES 4, 7, 8

Pseudodiaptomus lobipes GURNEY, 1907, pp. 27, 28, pl. 1, figs. 4-8.—SEWELL, 1924, p. 786, pl. 45, fig. 1.

Female.—The head is fused with the first thoracic segment. The last segment of the thorax is rounded, and has a small spine on each side. The abdomen has four segments, the first three having spines on the distal borders. The furcal rami are ciliate on the inner borders. The antennae have 21 segments and extend to the abdomen. In the fifth feet (pl. 22, fig. 4) the first segment of the exopod, in addition to the external distal spine, has, near the internal distal angle, a small oval projection. The second segment of the exopod has, besides the terminal hook, small spines of about equal length at the internal and external distal angles and a longer spine between the hook and the spine of the inner distal angle.

Male.—In the right fifth foot (pl. 22, fig. 7) there is a prominent rounded process on the interior of the terminal hook about midway of its length. The process of the second segment of the basipod of the left foot (pl. 22, fig. 8) is long, curved, and rounded at the end. The second segment of the left exopod is an oval plate with a spine about midway of its outer border and a row of small spines about midway of the inner border.

Length: Female, 0.35 mm; male, 0.95. These are measurements given by Gurney and must be incorrect; possibly the female is 1.35 mm.

Occurrence.—Found in Calcutta, India.

SCHMACKERIA POPPEI (Stingelin)

PLATE 22, FIGURES 5, 6; PLATE 23, FIGURE 1

Pseudodiaptomus poppei STINGELIN, 1900, pp. 200-204, pl. 14, figs. 6-10.

Female.—The head and the first thoracic segment are fused. The sides of the last thoracic segment are rounded; there are two dorsal spines on this segment and rows of small spines on its sides. The abdomen has four segments; the first three segments have spines on their distal borders. The first antennae have 22 segments. In the fifth foot (pl. 23, fig. 1) the first segment of the exopod has a rather stout external spine and a marked projection of the inner distal angle. The second segment of the exopod has an elongated terminal hook with a hook-shaped branch at its base, a stout terminal spine, and a small lateral spine.

Length, 1.36 mm.

Male.—In the right fifth foot (pl. 22, fig. 5) the exopod consists of three segments. The first segment has a spinous projection, which is as long as the second segment; the second segment has a short spine at the distal third of the outer border; the third segment is irregularly curved and about equal in length to the second segment; the terminal hook is short, nearly straight, and its sides are armed with short hairs. The second segment of the basipod of the left foot (pl. 22, fig. 6) has two processes extending distad to about the end of the first segment of the exopod; one process is spatulate and the other pointed. The first segment of the exopod has a spine at its outer distal angle. The second segment of the exopod is longer than the first, is irregular in outline and is lobed at the distal end; it has a stout dentate spine about midway of the outer border, a group of hairs about midway of its inner border, and, at the end, five short curved spines.

Length, 1.1 mm.

Occurrence.—Found in a pond in Celebes.

SCHMACKERIA SERRICAUDATUS (T. Scott)

PLATE 22, FIGURES 2, 3

Heterocalanus serricaudatus T. SCOTT, 1893, pp. 40, 41, pl. 2, figs. 43-48, pl. 3, figs. 1-7.

Pseudodiaptomus serricaudatus GIESBRECHT and SCHMEIL, 1898, p. 66.—A. SCOTT, 1902, p. 404, pl. 1, fig. 6.

Female.—Head narrowly rounded. The sides of the last thoracic segment are rounded and bear several small spines. The abdomen is 4-segmented, and the distal borders of the first three segments are armed with spines. The branches of the furcal rami are comparatively short. The first antennae have 22 segments and reach the third abdominal segment.

In the fifth foot (pl. 22, fig. 2) the terminal segment has a stout serrate hook at the inner angle, a slender spine at the outer angle, and a third shorter median spine.

Length, 1.15 mm.

Male.—The endopod of the right foot (pl. 22, fig. 3) is a dentate plate extending about one-half of the length of the first segment of the exopod. The first segment of the exopod has at its distal angles spinelike processes. The second segment of the exopod has a long, slender spine at its outer distal angle. The terminal hook is falciform, with a tumid base on which are two small spines. The left foot has, on the second segment of the basipod, a long slender sigmoid appendage, the endopod; this has short hairs on both inner and outer sides. Both segments of the exopod have elongated hooks; the second segment has, besides, a border of long hairs on the inner side of the base of the hook.

Length, 1.15 mm.

Occurrence.—Found in salt and brackish water in Gulf of Guinea, Red Sea, India, and Cape Colony.

SCHMACKERIA SMITHI Wright

PLATE 23, FIGURES 3, 4

Schmackeria smithi WRIGHT, 1928, pp. 592-597, pl. 12, figs. 1-3, 5-8.

Female.—The head and first thoracic segment are fused. There is a small spine on each side of the head. The sides of the last thoracic segment are rounded; there is a strong spine on the dorsal surface of the last thoracic segment on each side. The abdomen has four segments. Segments 1 to 3 have spines on the distal borders. The first segment has a rather prominent spine on each side. The antennae have 22 segments and extend to the second abdominal segment. The furcal rami are asymmetrical, and ciliate on the inner borders; the third seta is broader than the others. The second basal segment of the fifth foot (pl. 23, fig. 4) is approximately square, its inner and outer borders being convex. The first segment of the exopod has a spine near the outer distal angle and a hyaline lamella on the inner angle. The second segment of the exopod has a small external spine at the distal end, a stout, curved internal spine. The terminal hook is slightly curved and has a hook-shaped branch from the inner side of the base.

Length, 1.16 mm.

Male.—In the right fifth foot (pl. 23, fig. 3) a triangular process, the endopod, projects from the second basal segment. The first segment of the exopod is extended in a curved process which is dentate on the outer margin. The second segment of the exopod is

broad and of irregular form; it has a small spine on the inner border and a stout spine distad of the middle of the outer borders. The terminal hook has a rounded projection about midway of the inner margin. In the left foot the second basipod is expanded into two irregular processes extending distad. From the distal base of these processes is a lobular process on which is a small spine. The processes doubtless represent the endopod. The second segment of the exopod is rounded at the end; it has a stout dentate spine about midway of the outer border, a small spine on the inner border, and a small spine at the end.

Length, 0.96 mm.

Occurrence.—From Manila, Philippine Islands.

SCHMACKERIA TOLLINGERI (Sewell)

PLATE 23, FIGURE 2

Pseudodiptomus tollingeri SEWELL, 1919, pp. 2-5, pl. 10, fig. 8.

Female.—The head and first thoracic segment are fused. The rostrum is bifid. The last thoracic segment has a single spine situated toward the dorsal surface. The abdomen has four segments, the first three with spines at the distal ends. The genital segment has a transverse row of spines across the ventral side anterior to the genital opening. The third furcal seta is broader than the others. There are two egg sacs. The first antennae have 21 segments and extend to the second abdominal segment. Following is the description of the fifth foot as given by Sewell:

Each consists of a three-jointed exopod only * * * The second segment is produced at its distal internal angle in a lamelliform process which terminates in a sharp point: externally there is a single small needle-like spine. The third segment bears three spines and is produced externally in a bluntly rounded process; of the three spines, the outer is long and curved and in length is nearly equal to the whole limb; it is finely serrated along both borders: the middle spine is straight, about half the length of the outer one and is serrated on both margins; the inner spine is somewhat curved and is short and stout with coarse serrations on its inner, and fine teeth on its outer, border.

No figure of the female fifth foot is given, and from the above description it is impossible to make an intelligent description of the foot.

Length, 1.34 mm.

Male.—Plate 23, Figure 2, is a reproduction of Sewell's figure of the fifth feet. It is evident that he has omitted the first segments of the basipods. With this omission assumed, the following description has been prepared: From the second segment of the basipod of the right foot is a projection terminating in a spine and with a lobular branch on its external side; this probably is the endopod. The spinous prolongation of the external distal angle of the first segment of

the exopod reaches about one-half the length of the second segment. The terminal hook has a rounded dentate process on its inner border at about two-thirds of its length. The left foot has two elongated processes from the second segment of the basipod, one or both representing the endopod. The terminal segment has a stout dentate spine on its outer border and terminates in three pointed processes.

Length, 1.2 mm.

Occurrence.—Found in India in brackish water.

SENECELLIDAE, new family

Genus *SENECELLA* Juday, 1923

SENECELLA CALANOIDES Juday

PLATE 24

Senecella calanoides JUDAY, 1923, p. 205; 1925, pp. 1-6, pls. 1-3.

Female.—The head is indistinctly separated from the thorax; it has no rostrum or rostral filaments. The last thoracic segment is rounded and not expanded laterally. The abdomen (pl. 24, fig. 7) has four segments. The first segment exceeds in length the other three. The caudal rami are short and have short hairs on both the inner borders and the surface. The first antennae reach the second abdominal segment. The exopod of the second antenna (pl. 24, fig. 3) has seven segments. The first feet have 1-segmented endopods; the second, 2-segmented; and the third and fourth, 3-segmented. The endopod of the first foot has a ciliate shoulder or tuberos prominence (pl. 24, fig. 5) at about one-half the length of its outer border. The first basal segment of the fourth feet has, on its inner margin (pl. 24, fig. 2), a blunt spine, which has the appearance of a broken seta. The fifth feet are lacking.

Length, 2.65 mm to 2.88 mm.

Male.—The abdomen (pl. 24, fig. 6) is composed of four segments; the furcal rami are very short and have short hairs. Juday states that the male abdomen has five segments and has so figured it. An examination of a number of preparations by the author has failed to show the separation of the fifth segment. The caudal rami are shorter than in the female.

The right antenna is not geniculate, but is like the left. The mandible, maxillae, and maxilliped are smaller than in the female. The endopod of the first swimming foot is like that of the female. The first basal segment of the fourth foot (pl. 24, fig. 1) in place of the blunt spine found in the female has a cuplike depression in which there is a minute, acute spine.

On the right fifth foot (pl. 24, fig. 8) the endopod is slender, pointed, and extends beyond the second segment of the exopod. The

first segment of the exopod is about twice as long as broad and has a small spine on its outer margin at about three-fourths of its length. The second segment of the exopod is one-third as long as the first; it has a small curved spine near the distal end; this spine is turned inward across the segment. A narrow hyaline lamella extends along the inner side of the second segment and the base of the hook. The terminal hook is slender, recurved at the tip, and nearly as long as the whole right foot.

The second basal segment of the left foot (pl. 24, fig. 4) is twice as long as broad. The endopod is a triangular plate with sides about as long as the first segment of the exopod; the outer distal angle is drawn out in a slender, pointed process about as long as the sides of the endopod. The second segment of the exopod has a convex outer margin and a concave inner; there is a protuberance at the inner proximal angle and a small digitiform process and a spine at the termination.

Length, 2.45 mm to 2.55 mm.

Occurrence.—This species was first described from collections from Seneca, Cayuga, and Owasco Lakes, N. Y. It has also been found in Lake Timagami and Lake Nipigon in Canada. In 1894 the author found immature specimens of an unnamed copepod in Pine Lake, Mich. In 1898 he received from A. J. Woolman similar material collected in Lake Superior. It is now evident that both of these collections were of *Senecella calanoides*. It is characteristic of deep water and may eventually be found to have a wide distribution.

Remarks.—Juday correctly assigned this form to a new genus. It seems clear too that it must be placed in a new family, as it does not correspond to any recognized family. Therefore, the family name Senecellidae is here introduced for this interesting form.

LITERATURE CITED

BAJKOV, ALEXANDER.

1930. Biological conditions of Manitoban lakes. Contr. Can. Biol. and Fisher., new ser., vol. 5, no. 12, pp. 163-204, figs. 1-9.

BIGELOW, N. K.

1923. The plankton of Lake Nipigon and environs. Univ. Toronto Studies, no. 22, pp. 39-66.

BIRGE, EDWARD ASAHEL, and JUDAY, CHANCEY.

1914. A limnological study of the Finger Lakes of New York. Bull. U. S. Bur. Fisher., vol. 32 (1912), pp. 525-609, pls. 111-116, 23 figs.

BISHOP, SHERMAN CHAUNCEY, and CLARKE, NOAH T.

1923. A scientific survey of Turners Lake, Isle-au-Haut, Maine. New York State Mus. Bull. 251, following p. 192, illus.

BRADY, GEORGE STEWARDSON.

1891. A revision of British species of fresh-water Cyclopidae and Calanidae. Nat. Hist. Trans. Northumberland, Durham, and Newcastle-on-Tyne, vol. 11, pp. 68-120, 1 fig., 14 pls.

BREEMEN, P. J. VAN.

1908. Copepoden. Nordisches Plankton, Lief. 7, no. 8, 264 pp., 251 figs.

BREHM, VINCENZ.

1911. Einige Beiträge zur aussereuropäischen Entomostrakenfauna. Arch. Hydrobiol. und Planktonkunde, vol. 6, no. 4, pp. 486-488.

BRIAN, ALESSANDRO.

1926. Di alcuni copepodi d'acqua dolce dell'Argentina, raccolti dal Prof. F. Silvestri. Mem. Soc. Ent. Ital., vol. 4 (1925), fasc. 2, pp. 177-200, 24 figs.

BURCKHARDT, G.

1913. Wissenschaftliche Ergebnisse einer Reise um die Erde von M. Pernod und C. Schröter, III: Zooplankton aus ost- und süd-asiatischen Binnengewässern. Zool. Jahrb. (Abt. Syst.), vol. 34, pp. 341-472, 9 pls.

CAMPBELL, MILDRED H.

1929. Some free-swimming copepods of the Vancouver Island region. Trans. Roy. Soc. Canada, ser. 3, vol. 23, pt. 2, sect. 5, pp. 303-332, 3 pls.

CANU, EUGÈNE.

1888. Les copépodes libres marines du Boulonnais. Bull. Sci. France et Belgique, ser. 3, vol. 1, no. 1/3, pp. 78-106.

CLAUS, CARL.

1881. Über die Gattungen *Temora* und *Temorella* nebst den zugehörigen Arten. Sitz. Akad. Wiss. Wien, math.-nat. Classe, vol. 83, no. 3/4, pp. 482-493, 2 pls.

CLEVE, PER THEODOR.

1901. Plankton from the Indian Ocean and the Malay Archipelago. Kongl. Svenska Vet.-Akad. Handl., vol. 35, no. 5, pp. 1-58, 2 figs., 8 pls.

CREASER, EDWIN P.

1931. Some cohabitants of burrowing crayfish. Ecology, vol. 12, no. 1, pp. 243, 244.

DAHL, FRIEDRICH.

1894. Die Copepodenfauna des unteren Amazonas. Ber. Naturf. Ges. Freiburg, vol. 8, pp. 10-23, 1 pl.

DEKAY, JAMES ELLSWORTH.

1844. Zoology of New York, pt. 6: Crustacea. Natural history of New York, pt. 1: Zoology, pp. 1-70, 12 pls.

DELINT, GEERTJE M.

1922. Untersuchungen über Plankton-Copepoden in Niederländischen Gewässern. Intern. Rev. Ges. Hydrobiol. Hydrogr., vol. 10, pp. 76-90, 1 pl.

DODDS, GIDEON STANHOPE.

1926. Entomostraca from the Panama Canal Zone with description of one new species. Occ. Papers Mus. Zool. Univ. Michigan, no. 174, pp. 1-27, 3 figs.

ESTERLY, CALVIN OLIN.

1924. The free-swimming Copepoda of San Francisco Bay. Univ. California Publ. Zool., vol. 26, no. 5, pp. 81-192, 16 figs.

FADEEW, NIKOLAI NIKOLAEVITCH.

1926. Le lac Abraon et ses habitants (étude hydrobiologique). Trav. Sta. Biol. Caucase du Nord de Gorsky Inst. Agronomique, vol. 1, fasc. 2, pp. 1-18, 1 pl.

FORBES, STEPHEN ALFRED.

1882. On some Entomostraca of Lake Michigan and adjacent waters. Amer. Nat., vol. 16, pp. 537-542, 640-649, pls. 8, 9.

1891. On some Lake Superior Entomostraca. Rep. U. S. Comm. Fish and Fisheries for 1887, pp. 701-718, 4 pls.

1893. A preliminary report on the aquatic invertebrate fauna of the Yellowstone National Park, Wyoming, and of the Flathead region of Montana. Bull. U. S. Fish Comm. for 1891, pp. 207-260, pls. 37-42.

FOSTER, EDWARD.

1904. Notes on the free-swimming copepods of the waters in the vicinity of the Gulf Biologic Station, Louisiana. 2d Rep. Gulf Biol. Sta., 1903, Bull. 2, pp. 69-79.

FRÜCHTL, FRITZ.

1923. Cladocera und Copepoda der Aru-Inseln. Abh. Senck. Naturf. Ges., vol. 35, no. 4, pp. 449-457, pl. 26.

GIESBRECHT, WILHELM.

1882. Die freilebenden Copepoden der Kieler Foehrde. Vierter Bericht Comm. wiss. Unters. deutschen Meere Kiel, 1877-1881, pp. 87-168, 12 pls.

1896. Über pelagische Copepoden des Rothen Meeres, gesammelt vom Marinestabsarzt Dr. Augustin Krämer. Zool. Jahrb. (Abt. Syst.), vol. 9, no. 2, pp. 315-328, 2 pls.

GIESBRECHT, WILHELM, and SCHMEIL, OTTO.

1898. Copepoda. I: Gymnoplea. Das Tierreich, Crustacea, Lief. 6, xvi + 169 pp., 31 figs. Berlin.

GUERNE, JULES DE.

1886. Description du *Centropages grimaldii*, copépoide nouveau du Golfe de Finlande. Bull. Soc. Zool. France, vol. 11, pp. 276-285.

GUERNE, JULES DE, and RICHARD, JULES.

1889. Révision des calanoides d'eau douce. Mém. Soc. Zool. France, vol. 2, pp. 53-181, 60 figs., 4 pls.

GURNEY, ROBERT.

1907. Further notes on Indian fresh-water Entomostraca. Rec. Indian Mus., vol. 1, pp. 21-33, 2 pls.

HABERBOSCH, PAUL.

1916. Über arktische Süßwassercrustaceen. Zool Anz., vol. 47, no. 5, pp. 134-144.

HERDMAN, WILLIAM ABBOTT; THOMPSON, ISAAC COOKE; and SCOTT, ANDREW.

1897. On the plankton collected continuously during two traverses of the North Atlantic in the summer of 1897; with descriptions of new species of Copepoda; and an appendix on dredging in Puget Sound. Trans. Liverpool Biol. Soc., vol. 12, pp. 33-90, figs. 1-4, pls. 5-8.

HERRICK, CLARENCE LUTHER.

1882. Cyclopidae of Minnesota with notes on other copepods. 10th Ann. Rep. Geol. and Nat. Hist. Surv. Minnesota, pp. 219-233, 7 pls.

1883. Heterogenetic development in *Diatomus*. Amer. Nat., vol. 17, pp. 381-389, 499-505, pls. 5-7.

1884. A final report on the Crustacea of Minnesota included in the orders Cladocera and Copepoda. 12th Ann. Rep. Geol. and Nat. Hist. Surv. Minnesota, pp. 1-191, pls. a-v.

1887. Contribution to the fauna of the Gulf of Mexico and the South. Mem. Denison Sci. Assoc., vol. 1, no. 1, p. 56, 7 pls.

HERRICK, CLARENCE LUTHER, and TURNER, CHARLES HENRY.

1895. Synopsis of the Entomostraca of Minnesota. 2d Rep. State Zoologist, Geol. and Nat. Hist. Surv. Minnesota, pp. 1-525, 81 pls.

JUDAY, CHANCEY.

1915. Limnological studies on some lakes in Central America. Trans. Wisconsin Acad. Sci., Arts and Letters, vol. 18, pt. 1, pp. 214-250, 4 figs.

1923. *Senecella calanoides* Juday, n. gen., n. sp. Science, vol. 58, p. 205.

1925. *Senecella calanoides*, a recently described fresh-water copepod. Proc. U. S. Nat. Mus., vol. 66, art. 4, pp. 1-6, 3 pls.

JUDAY, CHANCEY, and MUTTKOWSKI, RICHARD ANTHONY VON.

1915. Entomostraca from St. Paul Island, Alaska. Bull. Wisconsin Nat. Hist. Soc., new ser., vol. 13, pp. 23-31, 6 figs.

KEISER, NICOLAUS.

1929. Über eine neue Art der Gattung *Eurytemora*—*Eurytemora composita* sp. nova. Zool. Anz., vol. 80, no. 10/12, pp. 301-305, 6 figs.

KEMMERER, GEORGE; BOVARD, JOHN FREEMAN; and BOORMAN, W. R.

1924. Northwestern lakes of the United States: Biological and chemical studies with reference to possibilities in production of fish. Bull. U. S. Bur. Fisher., vol. 39 (1923-1924), pp. 51-140, 22 figs.

KIEFER, FRIEDRICH.

1931. Zur Kenntnis der freilebenden Süßwassercyclopoden, insbesondere der Cyclopiden Nordamerikas. Zool. Jahrb. (Abt. Syst.), vol. 61, no. 5/6, pp. 579-620, 55 figs.

KIKUCHI, KENZO.

1928. Fresh-water Calanoida of middle and southwestern Japan. Mem. Coll. Sci. Kyoto Imp. Univ., ser. B, vol. 4, no. 1, pp. 65-79, 5 pls.

LILLJEBORG, WILHELM.

1853. De crustaceis ex ordinibus tribus: Cladocera, Ostracoda et Copepoda, in Scania occurrentibus xv + 222 pp., 27 pls. Lund.

MARSH, CHARLES DWIGHT.

1893. On the Cyclopidae and Calanidae of central Wisconsin. Trans. Wisconsin Acad. Sci., Arts and Letters, vol. 9, pp. 189-224, pls. 3-6.
1895. On the Cyclopidae and Calanidae of Lake St. Clair, Lake Michigan and certain of the inland lakes of Michigan. Michigan Fish Comm. Bull. 5, pp. 1-24, 9 pls.
1897. On the limnetic Crustacea of Green Lake. Trans. Wisconsin Acad. Sci., Arts and Letters, vol. 11, pp. 179-224, pls. 5-14.
1912. Notes on fresh-water Copepoda in the United States National Museum. Proc. U. S. Nat. Mus., vol. 42, pp. 245-255, 14 figs.
1913. Report on fresh-water Copepoda from Panama, with descriptions of new species. Smithsonian Misc. Coll., vol. 61, no. 3, pp. 1-30, 5 pls.
1918. Copepoda. In Ward and Whipple's "Fresh-water biology," pp. 741-789, figs. 1171-1243.
1920. The fresh-water Copepoda of the Canadian Arctic Expedition, 1913-18. Rep. Canadian Arctic Exped. 1913-18 (Southern Party 1913-16), vol. 7: Crustacea, pt. J: Freshwater Copepoda, 25 pp., 5 pls.
1924. A synopsis of the species of *Boeckella* and *Pseudoboeckella* with a key to the genera of fresh-water Centropagidae. Proc. U. S. Nat. Mus., vol. 64, art. 8, pp. 1-28, 35 figs.

MRÁZEK, ALOIS.

1894. Über eine neue *Schmackeria* (*Schm. hessei* n. sp.) aus der Kongo-Mündung. Sitz. böhm. Ges. Wiss., math.-nat. Classe, 1894, art. 24, pp. 1-3, 3 figs.
1901. Süßwasser-Copepoden. Ergebn. Hamburg Magalhaens. Sammelr., Lief. 6, no. 2, 29 pp., 4 pls.

NORDQUIST, OSCAR.

1888. Die Calaniden Finlands. Bidrag till kännedom af Finlands Natur och Folk, Finska Vet.-Soc., pp. 191-275, 10 pls.

OLOFSSON, OSSIAN.

1918. Studien über die Süßwasser fauna Spitsbergens. Zool. Bidrag Uppsala, vol. 6, pp. 183-636, 8 pls.

PEARSE, ARTHUR SPERRY.

1906. Fresh-water Copepoda of Massachusetts. Amer. Nat., vol. 40, pp. 241-251, 9 figs.

PESTA, OTTO.

1927. Ein Beitrag zur Kenntnis der Copepodenfauna von Argentinien. Zool. Anz., vol. 73, pp. 67-80, 6 figs.
1928. Die Tierwelt Deutschlands. Herausgeben von Prof. Dr. Friedrich Dahl, pt. 9: Krebstiere oder Crustacea. I: Ruderfusser oder Copepoda, 136 pp., 115 figs.

POPPE, S. ALBRECHT.

1880. Über eine neue Art der Gattung *Temora* Baird. Abh. Naturw. Verein Bremen, vol. 7, pp. 55-60, pl. 3.

POPPE, S. A., and MRÁZEK, ALOIS.

1895. Entomostraken des naturhistorischen Museums in Hamburg, 1: Die von Herrn Dr. F. Stuhlman auf Zanzibar und dem gegenüberliegenden Festlande gesammelten Süßwasser-Copepoden. Mitt. nat. Mus. Hamburg, vol. 12 (1894), pp. 123-134, 2 pls.

POPPE, S. A., and RICHARD, JULES.

1890. Description du *Schmackeria forbesi*, n. g. et sp. Calanide nouveau recueilli par M. Schumacker dans les eaux douces des environs de Shanghai. Mém. Soc. Zool. France, vol. 3, pp. 396-400, 1 pl.

RICHARD, JULES.

1891. Recherches sur le système glandulaire et sur le système nerveux des copépodes libres d'eau douce, suivies d'une révision des espèces de ce groupe, qui vivent en France. *Ann. Sci. Nat. Zool.*, vol. 12, pp. 113-270, pls. 5-8.

RYLOV, V. M.

1922. Free-swimming fresh-water Entomostraca (Eucopepoda), 126 pp., 71 figs. Moscow.
1924. Über zwei wenig bekannte *Heterocope*-Arten (Copepoda, Calanoida). *Zool. Anz.*, vol. 69, pp. 225-232, 11 figs.
1928. Über eine neue *Epischura*-Art aus dem fernen Osten (*Epischura chankensis* sp. nov.; Copepoda, Calanoida). *Zool. Anz.*, vol. 77, pp. 125-137, 13 figs.
1930. Keys to determination of fresh-water organisms of the U. S. S. R. fresh-water fauna, pt. 1: The fresh-water calanoids of the U. S. S. R., 288 pp., 88 figs.

SARS, GEORG OSSIAN.

1863. Oversigt af de indenlandske Ferskvands-Copepoder. *Forh. Vid.-Selsk. Christiania*, 1862, pp. 212-262.
1897. Pelagic Entomostraca of the Caspian Sea. *Ann. Mus. Zool. Acad. Imp. Sci. St. Pétersbourg*, vol. 2, pp. 1-73, 8 pls.
1898. The Cladocera, Copepoda, and Ostracoda of the Jana Expedition. *Ann. Mus. Zool. Acad. Sci. St. Pétersbourg*, vol. 3, pp. 324-359, pls. 6-11.
1900. On *Epischura baikalensis*, a new calanoid from Baikal Lake. *Ann. Mus. Zool. Acad. Sci. St. Pétersbourg*, vol. 5, pp. 226-238, 1 pl.
1902. An account of the Crustacea of Norway, vol. 4: Copepoda, 171 pp., 106 pls.+6 suppl. pls.

SCHACHT, FREDERICK WILLIAM.

1898. The North American Centropagidae belonging to the genera *Osphraticum*, *Limnocalanus*, and *Epischura*. *Bull. Illinois Lab. Nat. Hist.*, vol. 5, pp. 225-269.

SCHMEIL, OTTO.

1896. Deutschlands freilebende Süßwasser-Copepoden, pt. 3: Centropagidae. *Bibl. Zool.*, vol. 21, pp. 1-144, 12 pls.

SCOTT, ANDREW.

1902. On some Red Sea and Indian Ocean Copepoda. *Trans. Liverpool Biol. Soc.*, vol. 16, pp. 397-428.
1909. The Copepoda of the *Siboga* Expedition, pt. 1: Free-swimming, littoral, and semiparasitic Copepoda. *Siboga-Expedition, Monographie* 29a, 323 pp., 69 pls.

SCOTT, THOMAS.

1893. Report on Entomostraca from the Gulf of Guinea, collected by John Rattray, B. Sc. *Trans. Linn. Soc. London*, ser. 2, vol. 6, *Zool.*, pp. 1-161, 15 pls.

SEWELL, R. B. SEYMOUR.

1912. Notes on the surface-living Copepoda of the Bay of Bengal, I and II. *Rec. Indian Mus.*, vol. 7, pt. 4, no. 29, pp. 313-382, pls. 14-24.
1919. A preliminary note on some new species of Copepoda. *Rec. Indian Mus.*, vol. 16, pt. 1, no. 1, pp. 1-18, pls. 9, 10.
1924. Fauna of the Chilka Lake, Crustacea Copepoda. *Mem. Indian Mus.*, vol. 5, pp. 771-851, 16 pls.

SHARPE, RICHARD WORTHY.

1910. Notes on the marine Copepoda and Cladocera of Woods Hole and adjacent regions, including a synopsis of the genera of the Harpacticoida. Proc. U. S. Nat. Mus., vol. 38, pp. 405-436, 20 figs.

SMIRNOV, SERGIUS S.

1929. Beitrage zur Copepodenfauna Ostasiens. Zool. Anz., vol. 81, no. 11/12, pp. 317-329, fig. 9.

STEPHENSEN, K.

1913. Grønlands Krebsdyr og Pycnogonider (Conspectus crustaceorum et pycnogonidorum Groenlandiae), 479 pp. Copenhagen.

STINGELIN, THEODOR.

1900. Beitrag zur Kenntniss der Süßwasserfauna von Celebes. Entomotraca. Rev. Suisse Zool., vol. 8, pp. 193-207, 1 pl.

THOMPSON, ISAAC COOKE, and SCOTT, ANDREW.

1903. Report on the Copepoda collected by Professor Herdman at Ceylon in 1902. Rep. Govt. Ceylon Pearl Oyster Fisher., pt. 1, pp. 227-307, 1 fig., 20 pls.

(See also under Herdman, W. A.)

TOLLINGER, M. ANNUNZIATA.

1911. Die geographische Verbreitung der Diaptomiden und anderer Süß- und Brackwasser-Gattungen aus der Familie der Centropagiden. Zool. Jahrb. (Abt. Syst.), vol. 30, pp. 1-302, 178 figs., 4 pls.

WILLEY, ARTHUR.

1920. Report on the marine Copepoda collected during the Canadian Arctic Expedition. Rep. Canadian Arctic Exped. 1913-18 (Southern Party 1913-16), vol. 7: Crustacea, pt. K: Marine Copepoda, 46 pp., 70 figs.
1923. Notes on the distribution of free-living Copepoda in Canadian waters. Studies Biol. Sta. Canada, new ser., vol. 1, pp. 303-334.

WILLIAMS, LEONARD WORCESTER.

1906. Notes on marine Copepoda of Rhode Island. Amer. Nat., vol. 40, pp. 639-660, fig. 23.

WILSON, CHARLES BRANCH.

1929. The macroplankton of Lake Erie. Bull. Buffalo Soc. Nat. Sci., vol. 14, no. 3, pp. 94-135.
1932. The copepods of the Woods Hole region, Massachusetts. U. S. Nat. Mus. Bull. 158, 635 pp., 316 figs., 41 pls.

WRIGHT, STILLMAN.

1928. A contribution to the knowledge of the genus *Pseudodiaptomus*. Trans. Wisconsin Acad. Sci., Arts and Letters, vol. 23, pp. 587-600, 2 figs., 1 pl.

BIBLIOGRAPHY OF PAPERS ON COPEPODS BY CHARLES DWIGHT
MARSH

[IN THIS posthumous work, it seems fitting to present a full list of Doctor Marsh's contributions to the literature of the copepod crustaceans, on which he was a leading authority. The following bibliography was compiled by Miss Lucile McCain, of the division of marine invertebrates, and comprises 35 titles of papers published over a period of 43 years. A painstaking attempt has been made to make it complete, and several copepod specialists have cooperated by supplying titles.—EDITOR.]

1891. On the deep water Crustacea of Green Lake. Trans. Wisconsin Acad. Sci., Arts, and Letters, vol. 8, pp. 211-213.
Preliminary list of deep water Crustacea in Green Lake, Wisc., U. S. A. Zool. Anz., vol. 14, no. 370, pp. 275-276.
1893. Notes on the Copepoda of Wisconsin. Science, vol. 22, no. 544, pp. 3-4.
On the Cyclopidae and Calanidae of central Wisconsin. Trans. Wisconsin Acad. Sci., Arts, and Letters, vol. 9, pp. 189-224, pls. 3-6.
1894. On the vertical distribution of pelagic Crustacea in Green Lake, Wisc. Amer. Nat., vol. 28, no. 333, pp. 807-809.
On two new species of *Diaptomus*. Trans. Wisconsin Acad. Sci., Arts, and Letters, vol. 9, pp. 15-18, 1 pl.
1895. On the Cyclopidae and Calanidae of Lake St. Clair, Lake Michigan, and certain of the inland lakes of Michigan. Michigan Fish Comm. Bull. 5, pp. 1-24, 9 pls.
1897. On the limnetic Crustacea of Green Lake. Trans. Wisconsin Acad. Sci., Arts, and Letters, vol. 11, pp. 179-224, pls. 5-14.
1899. Methods of making microscopic preparations of Copepoda. Journ. Applied Microscopy, vol. 2, no. 3, pp. 295-296.
The plankton of fresh water lakes. Trans. Wisconsin Acad. Sci., Arts, and Letters, vol. 13, pt. 1, pp. 163-187. (Published also in Science, new ser., vol. 11, no. 271, pp. 374-389, 1900.)
1900. On some points in the structure of the larva of *Epischura lacustris* Forbes. Trans. Wisconsin Acad. Sci., Arts, and Letters, vol. 12, pp. 544-549, pls. 12, 13.
1903. On a new species of *Canthocamptus* from Idaho. Trans. Wisconsin Acad. Sci., Arts, and Letters, vol. 14, pt. 1, pp. 112-116, 10 figs.
The plankton of Lake Winnebago and Green Lake. Wisconsin Geol. and Nat. Hist. Surv. Bull. 12, sci. ser., no. 3, vi+94 pp. Madison.
1904. Report on the Copepoda. In Henry Baldwin Ward's "A biological reconnaissance of some elevated lakes in the Sierras and Rockies." Studies Zool. Lab. Univ. Nebraska, no. 60, pp. 146-149, pls. 30, 31.
1905. The groups and distribution of the North American species of *Diaptomus*. An address before the A. A. A. S. Abstract published in Science, new ser., vol. 21, pp. 270-271.
1906. Copépodes. In Maurice Neveu-Lemaire's "Les lacs des hauts plateaux de l'Amérique du Sud," pp. 175-188, pls. 17, 18. Paris.

1907. A revision of the North American species of *Diaptomus*. Trans. Wisconsin Acad. Sci., Arts, and Letters, vol. 15, pt. 2, pp. 381-516, pls. 15-28.
1910. A revision of the North American species of *Cyclops*. Trans. Wisconsin Acad. Sci., Arts, and Letters, vol. 16, pt. 2, pp. 1067-1135, pls. 72-81.
1911. On a new species of *Diaptomus* from Colorado. Trans. Wisconsin Acad. Sci., Arts, and Letters, vol. 17, pt. 1, pp. 197-199, pl. 10.
Structural abnormalities in Copepoda. Trans. Wisconsin Acad. Sci., Arts, and Letters, vol. 17, pt. 1, pp. 195-196, 9 figs.
1912. Notes on fresh-water Copepoda in the United States National Museum. Proc. U. S. Nat. Mus., vol. 42, pp. 245-255, 14 figs.
1913. Report on fresh-water Copepoda from Panama, with descriptions of new species. Smithsonian Misc. Coll., vol. 61, no. 3, pp. 1-30, 5 pls.
1915. A new crustacean, *Diaptomus virginicensis*, and a description of *Diaptomus tyrelli* Poppe. Proc. U. S. Nat. Mus., vol. 49, pp. 457-462, 7 figs.
1918. Copepoda. In Henry Baldwin Ward and George Chandler Whipple's "Fresh-water biology," pp. 741-789, figs. 1171-1243. New York and London.
1919. Report on a collection of Copepoda made in Honduras by F. J. Dyer. Proc. U. S. Nat. Mus., vol. 55, pp. 545-548, pl. 49.
1920. The fresh water Copepoda of the Canadian Arctic Expedition, 1913-18. Rep. Canadian Arctic Exped. 1913-18 (Southern Party, 1913-16), vol. 7: Crustacea, pt. J: Copepoda, 25 pp., 5 pls.
1924. A new locality for a species of *Diaptomus*. Science, new ser., vol. 59, no. 1535, pp. 485-486.
A synopsis of the species *Boeckella* and *Pseudoboeckella* with a key to the genera of the fresh-water Centropagidae. Proc. U. S. Nat. Mus., vol. 64, art. 8, pp. 1-28, 35 figs.
1926. Crustacés copépodes récoltés par M. Henri Gadeau de Kerville pendant son voyage zoologique en Syrie (Avril-Juin 1908). In Gadeau de Kerville's "Voyage zoologique d'Henri Gadeau de Kerville en Syrie," vol. 1, pp. 171-185, pls. 23-26. Paris.
On a collection of Copepoda from Florida, with a description of *Diaptomus floridanus*, new species. Proc. U. S. Nat. Mus., vol. 70, art. 10, pp. 1-4, 6 figs.
1929. Distribution and key of the North American copepods of the genus *Diaptomus*, with the description of a new species. Proc. U. S. Nat. Mus., vol. 75, art. 14, pp. 1-27, 16 figs.
1931. On a collection of Copepoda made in El Salvador by Samuel F. Hildebrand and Fred J. Foster of the U. S. Bureau of Fisheries. Journ. Washington Acad. Sci., vol. 21, no. 10, pp. 207-209.
The copepod genera *Broteas* Lovén, *Paradiaptomus* Sars, *Lovenula* Schmeil, *Mctadiaptomus* Methuen, and *Adiaptomus* Cooper. Journ. Washington Acad. Sci., vol. 21, no. 16, pp. 397-405, 3 figs.
1932. A new species of *Cyclops* from the Philippine Islands. Journ. Washington Acad. Sci., vol. 22, no. 7, pp. 182-184, 8 figs.
1933. Synopsis of the calanoid crustaceans, exclusive of the Diaptomidae, found in fresh and brackish waters, chiefly of North America. Proc. U. S. Nat. Mus., vol. 82, art. 18, pp. 1-58, 24 pls.
- ? The Crustacea of the plankton of western Lake Erie. (To be published in the Bulletin of the U. S. Bureau of Fisheries as a chapter in a general report on the lake.)